Micro-mineral profile in different grassland species

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Abstract

The aim was to investigate the micro-mineral profile of herbage as affected by grassland species, cutting time and seasonality and in relation to dairy cow requirements. The different grassland 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 profiles, not influenced by year. Among the legumes red clover (*Trifolium pratense*) had high concentrations of Co, Cu and Zn, white clover (*Trifolium repens*) of Mn and Fe, lucerne (*Medicago sativa*) of Se and lotus (*Lotus corniculatus*) of Co, Mn, Zn and Fe. Among the grasses, perennial ryegrass (*Lolium perenne*) generally had the highest concentrations of all the micro-minerals. Hybrid ryegrass (*Lolium hybridum*) had slightly lower concentrations than perennial ryegrass for all minerals. Meadow fescue (*Festuca pratensis*) had lower concentrations still, and timothy (*Phleum pratense*) had, with the exception of Zn, the lowest concentrations. In general, the mineral concentrations were higher in summer than in spring growth. During the growth Cu, Zn and Fe concentrations decreased, whereas Co, Se and Mg were unaffected. It was concluded that a mixture of red clover and perennial ryegrass had the best profile of micro-minerals for cattle feeding.

Keywords: micro-mineral, grass, legumes, mineral profile, organic production

Introduction

Inorganic micro-minerals are usually allocated as supplements in dairy cow feeding to avoid deficiency. However, 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 micro-minerals is to choose plant species with different micro-mineral profiles that can complement each other. A range of plant species could thus help to balance the mineral status of the diet. For examining the possibility to affect the mineral profile in the herbage we studied the effect of grassland species, cutting time and seasonality. As the species normally grow in mixtures with grass and legumes and the species affected each other's mineral uptake, we examined the species under mixed growing conditions. This paper focuses on a limited range of micro-minerals in relation to dairy cattle requirements and feeding.

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 (9°34′E, 56°29′N) 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 second 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). Perennial ryegrass and white clover was thus the reference mixture.

The plots were fertilized with 300 kg total N in cattle slurry with the following distribution per cut: 100, 80, 60, 60 and 0 kg N. The plots were irrigated at drought stress.
The dry matter yield and the botanical composition measured by hand separation were determined at each harvest. Mineral composition was measured in the hand-separated species three times during spring growth in May and ~~for~~ the second regrowth in August in 2007 and 2008. The mineral composition of white clover and perennial ryegrass was measured in samples of the mixture with these two 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).

Results

The species had very different micro-mineral contents and profiles (Table 1). Among the legumes, all grown together with perennial ryegrass, red clover had the highest concentrations of Co, Cu and Zn, whereas white clover had the highest concentrations of Mn and Fe, and lotus had high concentrations of Co, Mn, Zn and Fe. In general, lucerne had low concentrations of both macro-minerals (not shown) and micro-minerals, except for Se. Lotus also had a low concentration of macro-minerals, except for K, which was considerably higher than in the other legumes (data not shown).
Among the grass species, all grown together with white clover, perennial ryegrass had, in general, a high concentration of micro-minerals as well as macro-minerals (not shown). In contrast, timothy had, in general, low concentrations both of macro-minerals (not shown) and micro-minerals, with Cu and Zn as the only exceptions.
Comparing legumes and grasses, the legumes had significantly ($P < 0.05$) higher concentrations of Co, Se and Cu than grasses, and grasses had significantly higher concentrations of Mn than legumes.

Table 1. Annual dry matter (DM) yield of the mixture (t ha^{-1}). Proportion of the species in the two species mixtures (% of DM) and concentration of micro-minerals in DM (mg kg^{-1}) as a mean of samples in spring growth and summer growth. Different letters within variable and group indicate significant differences ($P < 0.05$). Table value for requirement is shown at the bottom of the table.

	DM yield	Propor-tion	Co	Se	Mn	Cu	Zn	Fe
Mixed with perennial ryegrass								
White clover	12.6^{b}	37.2^{c}	0.048^{b}	0.019^{c}	51.4^{a}	6.7^{b}	17.9^{b}	89.4^{a}
Red clover	15.6^{a}	78.8^{a}	0.057^{a}	0.025^{b}	42.9^{b}	8.7^{a}	22.2^{a}	61.3^{b}
Lucerne	13.4^{b}	66.3^{b}	0.041^{c}	0.033^{a}	38.0^{c}	6.5^{b}	18.6^{b}	63.4^{b}
Lotus	9.6^{c}	18.8^{d}	0.054^{a}	0.022^{bc}	47.8^{a}	6.2^{b}	22.4^{a}	81.7^{a}
Mixed with white clover								
Per. ryegrass	12.6^{b}	62.8^{b}	0.031^{a}	0.019^{a}	68.1^{a}	6.7^{a}	22.6^{a}	96.1^{a}
Hybrid ryegrass	13.1^{ab}	72.9^{a}	0.023^{b}	0.018^{ab}	56.8^{b}	6.2^{ab}	20.4^{b}	78.0^{b}
Meadow fescue	13.3^{a}	72.4^{a}	0.023^{b}	0.016^{bc}	56.9^{b}	5.1^{c}	15.5^{c}	75.5^{b}
Timothy	11.8^{c}	63.1^{b}	0.016^{c}	0.014^{c}	46.1^{c}	5.9^{b}	24.3^{a}	72.6^{b}
Dairy cow requirement (NRC, 2001)								
Dietary content	-	-	0.11	0.3	14	11	48	15

During the three-week period in spring and summer growth, the concentrations of Co, Se and Mn were constant for both legumes and grasses, even when herbage dry matter increased significantly (Table 2). The Cu, Zn and Fe concentration, on the other hand, decreased over time. Harvesting at an earlier development stage would thus increase the relative contents of these three minerals.

The concentrations of the micro-minerals were higher ($P < 0.05$) in summer than in spring growth (Table 2); also when comparing at the same herbage mass.

Table 2. Concentration of micro-minerals in DM (mg kg^{-1}) as a mean of species, and herbage DM mass (t ha^{-1}) as a mean of mixtures during a three-week period. Different letters within variable and period indicate significant differences ($P < 0.05$).

		Co	Se	Mn	Cu	Zn	Fe	DM-yield
May	One week before	0.030	0.019	48.7	5.73^{a}	20.7^{a}	73.2^{a}	2.5^{c}
	Cut	0.030	0.018	50.1	5.23^{b}	19.0^{b}	64.0^{b}	3.3^{b}
	One week after	0.030	0.018	48.7	4.60^{c}	17.5^{c}	56.9^{c}	4.4^{a}
August	One week before	0.045	0.023	53.0	8.11^{a}	22.9^{a}	95.5	2.5^{c}
	Cut	0.044	0.022	52.7	7.82^{ab}	22.2^{a}	89.6	2.9^{b}
	One week after	0.040	0.022	52.3	7.49^{b}	20.7^{b}	84.4	3.5^{a}

Discussion and conclusion

In this experiment there were significant differences in mineral content and profile between grassland species. This indicates a potential for optimizing dairy cow micro-mineral intake from home-grown herbage by manipulating grassland species composition. For example, the highest Co concentration of 0.051 mg kg^{-1} in 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^{-1} in DM between the different mixtures. The calculations are given as the mean of year and taking the proportion of the species (Table 1) into account. Despite species differences, the micro-mineral contents were generally above dairy cow requirements according to the NRC (2001) (Table 1) for Mn and Fe, close to requirement for Cu and Zn, and below requirements for Co and Se. However, there are indications that commercial organic micro-minerals might have a significantly higher bioavailability in dairy cows than inorganic micro-minerals, and that supplementation can be reduced by 25% when using organic minerals (Spears, 1996; Nocek *et al*., 2006).
Overall, the red clover/perennial ryegrass mixture had the highest concentrations of Co, Cu, Zn and Se and at the same time low concentrations of Mn and Fe. This mixture is therefore concluded to have the best micro-mineral profile in this experiment in relation to the recommended profile and level for dairy cow feeding.

References

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