A discussion of norms for S supply in organic farming based on content in forage and ruminant performance in Norway

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Key words: forage, dairy cattle, deficiency, grassland, sheep

Abstract

The content of sulphur (S) in grassland on 27 Norwegian organic farms with dairy or sheep production was investigated in 2001 and 2002. The forage content of S was below the norms (2 g S kg DM^{-1}) for both plants and animals in a large proportion of the samples. The average S content in forage at dairy farms was 1.4 g S kg DM^{-1} and at sheep farms 1.5 g. Even on grasslands with low plant S content (<1 g S kg DM^{-1}), S-fertilization did not increase yields and increased the plants' S content only very slightly. No indications of S deficiency were observed on the dairy farms. For one sheep farm with a forage S content of 1.1 ± 0.1g S kg DM^{-1}, brittle and short winter wool was reported.

Introduction

Fertilization and mineral supplementation in organic farming systems must be based on the guidelines for organic farming from IFOAM and the set of rules that regulate organic farming practices. The plant and animal requirements for S will depend on growth rate and yield. In organic farming systems, the rather low supply of nitrogen from the soil and diet is an important reason for the low production levels that often are targeted and obtained (e.g. Berry et al. 2002).

If there is a risk that animals are suffering because of too low a mineral supply, or if there is a risk that the production is severely limited, farmers may be allowed to add extra sulphur (S). However, supplementation with any single element may cause new disorders in plants or animals. For example, increased S content in the fodder ration for ruminants may induce secondary copper deficiency in a forage rich diet with a high content of molybdenum (Underwood & Suttle, 1999) and may reduce selenium uptake by both plants (Hopper & Parker, 1999) and ruminants (Ivancic & Weiss, 2001).

Because development of relevant norms demand a lot of resources, extension services often use recommendations developed for conventional agriculture. In case of S, a feed content of 2.0 g S kg DM^{-1} for dairy cattle is recommended in Norway (NRC standards, National Research Council, 2001), and the same herbage content for grasses and clover. Because of the high S-content in wool, NRC recommend a S content in feed ration of 1.8 to 2.6 g S kg DM^{-1} for young lambs and 1.4 to 1.8 g S kg DM^{-1} for mature ewes (Underwood & Suttle, 1999).

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The aim of this paper is to discuss the present recommendations for supply of S to forage plants, dairy cattle and sheep in relation to the S content recorded in forage from Norwegian organic dairy and sheep farms.

Materials and methods

A survey was carried out on organic sheep (13) and dairy (14) farms in Norway. Samples of standing forage crop were taken from each of three plots in three different grasslands on each of the farms in 2001 and 2002 (Govasmark et al. 2005). On most farms there were two harvests annually, except for on five mountain farms, where only one cut was taken. The botanical composition of the grasslands varied greatly among the farms. The median content of clover was 13 % and 28 % for the first and second harvest, respectively. The corresponding lower - upper quartiles were 5-23 % and 18-44 %. None of the farmers applied any kind of mineral fertilizer to their soils.

There were large variations in feed ration and milk yield among the 14 dairy farms. The fodder ration consisted of 7 to 24 % concentrates (mainly homegrown barley and oats), 20 to 40 % pasture, and the rest silage and hay. The milk yield varied from 3000 to 6300 kg per cow per year, with an average of 4600 kg. The majority of the herds had calving time distributed over a large part of the year. On the sheep farms the main forage in winter was hay. In summer the sheep grazed in mountain areas or other outlying fields. Only small amounts of concentrate before and after lambing were used. Seaweed meals as supplied on four dairy farms contained 2.5-3.5 % S. The rest of the farms did not supply any S beyond S occurring in herbage and cereals.

To investigate whether S fertilization increased S content, yield, and the protein content of the forage, trials were conducted in established grasslands on organic farms; three in 2002, seven in 2004, and five in 2005. In 2002, S was applied in spring as $MgSO_4$ at rates of 0, 30 and 60 kg S ha^{-1}, and in 2004 and 2005 S was applied in spring as $CaSO_4$, Na_2SO_4 and K_2SO_4 at rates of 0, 20 and 40 kg S ha^{-1}. In all years herbage samples were taken in mid-June and mid-August at the first and second harvests. Timothy (*Phleum pratense*) and red clover (*Trifolium pratense*) were collected separately on each plot for S and N analysis.

Results

In the farm survey, the forage S content varied from 0.8 to 3.1 g S kg DM^{-1}in the first cut and from 1.0 to 3.1 in the second. Weighted mean values for content of S in forage from dairy and sheep farms were respectively 1.4 and 1.5 g S kg DM^{-1}. All forage samples from dairy farms had less than 2.0 g S kg DM^{-1}at first cut, and 79% at second cut; 13% and 1% had less than 1.0 g S kg DM^{-1}at first cut and second cut, respectively. On the sheep farms, 91% of forage from first and 33% of forage from second cut had less than 2.0 g S kg DM^{-1}, and 54 and 9 % had less than 1.4 g S kg DM^{-1}. Only two of the total of 110 forage samples collected from sheep farms contained less than 1 g S kg DM^{-1}. The S content of oats and barley grown on some of the farms varied from 1.4 to 1.7 g S kg DM^{-1}.

In spite of low content of crude protein, the forage N/S ratio was high, and was higher than 12, the recommended value from NRC, in 62 and 70 % of all forage samples from first and second cut, respectively. Neither forage protein nor forage S content had a clear relationship to milk yields. The urea concentration in milk was generally low (3.6 mmol/l).

S fertilization did not increase either the yield or the protein content in the field trials, but had a small but significant effect on forage S content at most sites (Table 1).

Tab. 1: Yield (t ha^{-1} yr^{-1}) and content of sulphur (S) (g kg DM^{-1}) in red clover and timothy after application of 0 and 20 kg S ha^{-1} yr^{-1} as $CaSO_4$; mean of four fields with two harvests in 2004 and 2005 ± std dev.

	First cut			Second cut		
Kg S ha^{-1} yr^{-1}	0	20		0	20	
DM Yield[a]	5.6 ±1.6	5.6 ±1.3	n.s.	3.7 ±1.4	3.7 ±1.3	n.s.
S Timothy[b]	1.0 ±0.1	1.1 ±0.1	***	1.5 ±0.5	1.7 ±0.6	*
S Red clover[b]	1.4 ±0.2	1.5 ±0.2	***	1.2 ±0.2	1.3 ±0.2	n.s.

[a]n=16, [b]n=8,* significant for P<0.05, *** significant for P<0.001

Discussion

The S content in forage was much lower than recommended for cattle and sheep. Supplementation with concentrates based on barley and oats did not improve the S supply, as indicated by the low S content in grain produced on the farms in this investigation. Thus the S content in the whole fodder rations was low, as seaweed was supplied only on four farms. However, no indications of S deficiency were observed on the dairy farms.

If the supply of N relative to S was too high in the herds studied here, the content of urea in the milk would probably have been considerably higher than recorded, as observed by Qi (1992). Even though 54% of the main harvests (first cut) on the sheep farms contained less S than the lower limit of the recommendations from NRC, no symptoms of deficiency were observed, except on the farm with the lowest S and protein content in the forage. On this farm there were problems with brittle and short winter wool. Lack of symptoms of S-deficiency cannot be caused by the animals using stored S in periods with low S-supply, as sulphur is mainly spent in muscle and the mammary gland, and excess sulphur will be excreted (Underwood & Suttle, 1999). From these observations it may be suggested that the recommendations for S supply are higher than the requirement for dairy cattle and sheep with fodder rations given on these organic farms.

However, the symptoms of S deficiency in ruminants are not specific. S deficiency may result in reduced appetite and digestibility of forage, which is not easy to identify and which may be caused by other factors too (Underwood & Suttle, 1999). The recommendations are also ambiguous. In the British standards (ARC, 1980) the suggested minimum is from 1.0 to 1.5 g S kg DM^{-1}. The recommendations for S supply to sheep and cattle needs to be critically evaluated in view of the moderate to low intensity levels that are found in organic farming. However, the recommendations may also be too high for conventional agricultural systems.

The lack of response to S application observed in the field trials can be explained by factors other than S limiting plant growth on these farms. However, we are surprised that the yield responses were so low. At some sites the S content in red clover was less than half the level of 2 g S kg DM^{-1} that is often used as a marginal value for optimal plant growth. We observed similar results for potassium (K) (Øgaard and Hansen, in prep.). Even with low concentrations of K in grassland (< 15 g K kg DM^{-1} in most cases), K fertilization did not increase yields, either alone or in combination with

additional S-supply. N-limited soil-plant-animal systems like those studied here will seldom respond to inputs of other nutrients, as stated by Liebig. The low N availability should be taken into account when extension services are evaluating the need for supplementation of S and other elements in organic farming systems.

Since increased N intensity of farming systems decreases their N efficiency (Bleken et. al, 2005) and increases the N surplus and nitrous oxide emissions (Olesen et. al., 2006), the effects of increased intensity level should be taken in to account in the further development of organic farming systems.

Conclusions

Except for the symptoms of S-deficiency in wool on one sheep farm, no clear symptoms of S deficiency were observed in the investigated sheep and cattle herds despite S content in roughage that is much lower than what is recommended by the extension service. S fertilization did not increase either the yield or the protein content in the field trials. In most trials, fertilization had a small but significant effect on S content in the herbage

Acknowledgments

The Norwegian Research Council is acknowledged for financing this study as part of the research program: “Mineral content in plants and mineral supply for ruminants in organic agriculture”. Espen Govasmark, Håvard Steinshamn, Turid Strøm, and Martha Ebbesvik are acknowledged for valuable discussions.

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