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Benefit of sulfate fertilisation in Alfalfa- and clover grass mixtures in organic

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Abstract

*In this study, alfalfa- and clover-grass mixture was fertilized with MgSO4 and CaSO4 (treatments: 1: no treatment, 2: MgSO4 80 S * ha^{-1}, 3: CaSO4 80 kg S * ha^{-1}). The yield, N-content and S-content of the alfalfa- and clover-grass-mixture was clearly positive affected by sulphur fertilization.*

Introduction

Alfalfa- and clover-grass-mixtures are of high importance for organic farming systems. Their ability to fix atmospheric nitrogen results in high N input into the farming system. It is well known, that nitrogen fixation and plant growth of legumes is affected by sulphur (S) deficiency (Scherer et al. 2007, Varin et al. 2010).

Because of the clean air act 91, a decline in S deposits on agricultural crops has been observed throughout Europe during the last decades (Zhao et al. 2002). In consideration of these facts it seems to be obvious, that S-shortage is a common problem in practice of organic farming systems in many regions of Europe.

Material and methods

In the years 2010 and 2011, S response trials were at Gladbacherhof, organic trial station of the University Gießen (Villmar Hesse Germany, mean annual temp. 9.3°C, annual precipitation 670 mm, soil texture: clayloam, dairy farm, 1 LU cattle ha-1).

Two sulfate fertilization treatments (80 kg S ha-1 resp. as MgSO4 or CaSO4) were compared with a control (no S) in alfalfa-clover-grass. The experiment was conducted in the second year after establishment (underseed in summer barley) of the alfalfa-clover-grass, and was repeated in two series (2010 and 2011 on different fields). Fertilization was split in 60 kg S ha-1 at the beginning of the growing season (25.03.2010 resp. 10.03.2011) and 20 kg S ha-1 after the first cutting (10.06.2010 resp. 06.06.2011). The experiment was conducted with 4 replications in a randomized block design. Each plot was 3 m x 10 m.

Soil samples (0-60 cm depth) were taken at the beginning of the vegetation period (March) and by harvest. Samples from each plot were analyzed for available S (Smin) using the 0,0125 mol L-1 CaCl2 extractable S method and ICP-OES at 181,972 nm.

Results

In both years (2010 and 2011) S fertilization increased plant available S in the 0-60 cm soil layer (Table 1).

Tab. 1: Smin kg ha-1 0-60 cm depth, different S treatments, Gladbacherhof

	after fertilizing	first cut	second cut	third cut	fourth cut
2010					
Control S 0	2,0	2,8	3,0	0,0	no result
$MgSO_4$ S 80	40,5	120,1	59,0	44,7	no result
$CaSO_4$ S 80	20,0	39,4	48,0	38,5	no result
2011					
Control S 0	7,15	4,1	4,6	9,2	28,8
$MgSO_4$ S 80	87,9	51,7	139,2	85,9	77,3
$CaSO_4$ S 80	49,9	33,3	93,3	60,9	74,2

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The dry matter yield in the control was with 7,6 t ha^{-1} and 9,8 t ha^{-1} in 2010 and 2011 respectively significant lower than in the sulfate fertilized treatments (Table 2).

Tab. 1: Smin kg ha^{-1} 0-60 cm depth, different S treatments, Gladbacherhof

	treatment	first cut	second cut	third cut	fourth cut	Σ
2010						
yield DM mixture (t ha^{-1})	Control	2,72	1,66	2,01	1,24	7,63 a
	$MgSO_4$	3,13	2,97	3,88	2,08	12,06 b
	$CaSO_4$	3,44	2,74	3,56	2,06	11,08 b
S concentration % DM legumes	Control	0,33 a	0,16 a	0,16 a	0,13 a	
	$MgSO_4$	0,35 a	0,43 b	0,29 b	0,20 b	
	$CaSO_4$	0,35 a	0,38 b	0,28 b	0,21 b	
S concentration % DM grass	Control	0,44 a	0,20 a	0,22 a	0,21 a	
	$MgSO_4$	0,44 a	0,67 b	0,50 b	0,34 b	
	$CaSO_4$	0,41 a	0,64 b	0,52 b	0,35 b	
N concentration % DM legumes	Control	3,76 a	2,36 a	2,89 a	2,64 a	
	$MgSO_4$	4,39 b	3,38 b	3,49 b	2,97 b	
	$CaSO_4$	4,21 ab	3,42 b	3,54 b	3,01 b	
N concentration % DM grass	Control	2,19 a	2,05 a	2,55 a	2,00 a	
	$MgSO_4$	2,49 a	2,58 b	3,30 b	2,82 b	
	$CaSO_4$	2,36 a	2,51 b	3,46 b	2,78 b	
N yield mixture (kg ha^{-1})	Control	89,24	38,15	56,30	29,11	212,80 a
	$MgSO_4$	120,96	96,08	134,87	59,80	411,71 b
	$CaSO_4$	124,01	88,85	125,75	64,73	404,34 b
2011						
yield DM mixture (t ha^{-1})	Control	3,82	2,01	2,73	1,23	9,79 a
	$MgSO_4$	4,86	4,43	2,27	2,35	13,91 b
	$CaSO_4$	4,50	3,90	2,26	2,56	13,22 b
S concentration % DM legumes	Control	0,15 a	0,12 a	0,14 a	0,16 a	
	$MgSO_4$	0,19 b	0,24 b	0,24 b	0,33 b	
	$CaSO_4$	0,18 ab	0,25 b	0,25 b	0,31 b	
S concentration % DM grass	Control	0,14 a	0,17 a	0,18 a	0,20 a	
	$MgSO_4$	0,26 b	0,41 b	0,41 b	0,45 b	
	$CaSO_4$	0,24 b	0,45 b	0,48 b	0,52 c	
N concentration % DM legumes	Control	2,59 a	2,61 a	2,79 a	3,19 a	
	$MgSO_4$	3,17 b	3,09 b	3,12 a	3,66 a	
	$CaSO_4$	3,07 b	3,13 b	3,12 a	3,79 a	
N concentration % DM grass	Control	1,81 a	2,09 a	2,27 a	2,54 a	
	$MgSO_4$	2,16 b	3,26 b	3,78 b	4,28 b	
	$CaSO_4$	2,14 b	3,03 b	3,58 b	4,29 b	
N yield mixture (kg ha^{-1})	Control	85,67	49,19	73,90	37,75	246,52 a
	$MgSO_4$	140,60	137,13	70,87	86,71	435,31 b
	$CaSO_4$	125,08	121,07	71,21	97,55	414,91 b

Discussion

S levels of soil

The S availability in the unfertilized control arranged during the growing periods on a very low level (from 2,0 kg S ha^{-1} to 9,2 kg S ha^{-1}). Only in September 2011 (not shown) there was an increase of S up to 28,8 kg S ha^{-1} in the control. This might be a result of enhanced mineralization processes due to higher microbiological activity in the later vegetation period (Scherer 2009).

Yield and quality

Fertilizing S increased yield 2010 about 50 % and 2011 about 30 %, both MgSO4 and CaSO4. Particular the legumes were positively influenced by S fertilization, whereas the grass was not affected.

S fertilization increased S concentration in the shoots (legumes and grass) and in connection with higher yield the harvested S amount, in the sum of the four cuts 18,3 kg S ha-1 in the control plots and about 40 kg S ha-1 in the S-fertilized plots. The S concentration in the shoots clearly increased only after the first cut (< 0,2% (DM) no S; > 0,2% (DM) with S).

Sulfate fertilization resulted in considerable increased N yield of the alfalfa clover grass mixture. This was mainly a result of higher N concentration in the leguminous plants in combination with higher growth of this fraction. The control mostly failed below 3 % (DM) while N concentration in fertilized plots reached up to 3,5 % (DM). In both years S fertilizing led to a surplus of 200 kg N ha-1 in the shoot mass compared to no S fertilizing.

The results suggest that adequate S supply is of crucial importance for leguminous forage crops. Under S deficiency growth and N accumulation was significantly decreased and resulted in a dramatic reduction of N yield. That means a decline of N input into the whole production system. Providing adequate amounts of plant available S to leguminous forage crops is therefore an important tool to maintain productivity of ecological production system.

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