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Plant availability of sulfur from organic fertilisers

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Abstract

Short term S availability markedly depends on C/S ratio (r2=0.95), and to a less degree on SO42- content (r2=0.50) of organic fertilisers. In pot experiments highest mineral fertiliser equivalents of 77 and up to 59% were obtained with urine (C/S 11) and sewage sludge (C/S 11-28) followed by slurry (C/S 81), stable manure (C/S 84) and biocompost (C/S 70) with equivalents of 17, 13, and 8%. Long term S effect is related to an increased S release potential in soil and in consequence a higher net S mineralisation.

Introduction

During the last 15 years S immissions were reduced from 30 to 6 kg ha-1 (average in Bavaria, 1999). Therefore sufficient S supply of plants (20 –70 kg ha-1) requires additional S fertilisation. For optimising the use of organic fertilisers, the short and long term S availability has to be considered. The S release is thought to correlate with SO42- content and C/S ratio (Eriksen, 1997). Critical C/S ratios for a S net mineralisation from organic materials vary from 200 (Barrow, 1960) to 60–80 (Janzen and Ellert, 1998). Sulfur from catch crops (C/S ratio 167-234) proved to be unavailable for the following crop and induced S immobilisation (Gutser and v. Tucher, 2000).

Subject of this study was to investigate the relationship between C/S ratio and short term S availability of organic fertilisers (pot experiments). In addition, long term S release was deduced from net mineralisation in field experiments.

Materials and methods

Short term S availability of organic fertilisers (characterised in Table 1) is determined by S uptake of optimally fertilised (N, P, K, Mg) wheat (growth period 110 d) followed by mustard (30 d) in pot experiments (5.5 kg loamy sand, pH 6.0, 0.1 mg SO4-S 100 g-1 pot-1). Organic fertilisers are compared with mineral fertilisation. S dose: 100 mg St and for K2SO4 in addition 45 mg S pot-1. For N fertilisation NH4+-N content of organic fertilisers is taken into account.

Table 1. Characterisation of organic fertilisers

Organic Fertiliser	*Dry M.* %	S_t mg g TS^{-1}	SO_4-S % S_t	*C/S*
urine	*2.4*	*2.4*	*64*	*11*
sewage sludge 1	*25.5*	*8.1*	*2*	*11*
sewage sludge 2	*3.1*	*10.0*	*30*	*28*
slurry (cattle)	*8.3*	*5.2*	*16*	*81*
stable manure	*18.9*	*5.1*	*3*	*84*
biocompost	*82.2*	*3.3*	*4*	*70*
*catch crops**	*9.5-16.1*	*1.6-2.5*	-	*167-233*

* *Gutser and v. Tucher (2000)*

S effect is calculated as mineral fertiliser equivalent:

S uptake from organic fertiliser in % of S uptake from mineral fertiliser (control subtracted).

Net S mineralisation is determined in incubation studies without plants over a period of 255 days. The additive S effect of long term fertilisation is calculated in field (March–July 1999) by S net mineralisation on foil covered fallow plots (silty loam, 0-25 cm). Treatments: control and slurry (Æ 83 kg NH4+-N equal to 1200 Corg ha-1 a-1) since 1980, biogenic waste compost (biocompost) (Æ 100 and 200 kg Nt equal to 1450 and 2900 kg Corg ha-1 a-1) since 1992.

S is analysed in plants by ICP after microwave digestion, in soil by elemental analysis (St), and by anionic chromatography (SO42-) after extraction with CaCl2.

Results

Short term S effect in incubation experiments

Comparable to mineral fertilisation, sewage sludge 2 and in particular urine markedly increase SO42- content of soil (Figure 1). This rise in SO42- starts within the first 30 days and continues during the whole period (255 d). Slurry, biocompost, and manure release significantly less S. Biocompost even results in a weak S immobilisation on soils with a higher SO42- level (data not shown). Mineral fertiliser equivalents after 120 days are 86 and 50 % for urine and sewage sludge and 13, 12, and 2 % for slurry, manure and biocompost, respectively.

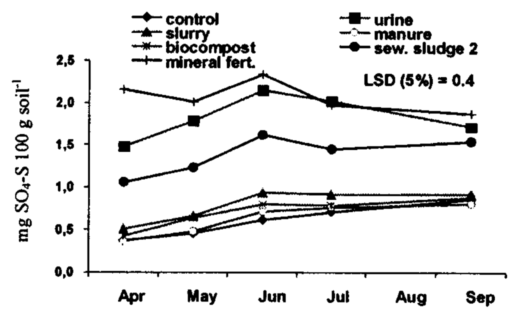

Figure 1. Sulfate content of soil following S fertilisation.

Short term S effect in pot experiments with plants

Wheat accounts for 85-90% of the total S uptake (Figure 2). The uptake significantly correlates with the level of S fertilisation (K2SO4). Within the organic fertilisers, urine application (mineral fertiliser equivalent: 77%) results in a very high S utilisation, followed by sewage sludges (59 and 50 %). Slurry (17%), manure (13%), and biocompost (8%) show only a weak effect. Fertiliser SO42- content only explains 51 % of the total S uptake. Sludge 1 and 2 differ in SO42- content (2 and 30% of total S), although S uptake is similar. Compared to SO42- content, C/S ratio of organic fertilisers (Figure 3) is much more correlated to the differences in S uptake (r^2=0.95). This regression also integrates the short term S immobilising effect of catch crops (C/S ratio 167-233, Gutser and v. Tucher, 2000). The critical C/S ratio of organic fertilisers is calculated to be about 80.

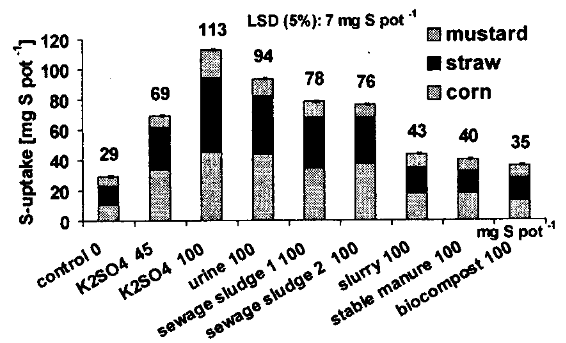

Figure 2. Utilisation of sulfur from organic fertilisers by wheat (grain and straw) and mustard.

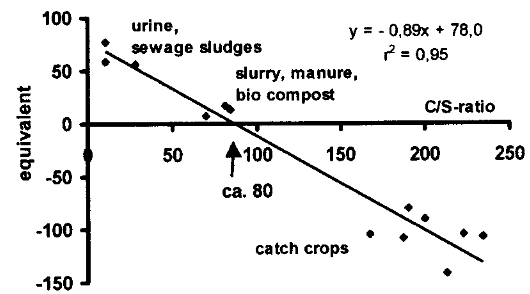

Figure 3. Regression between C/S ratio and short term S availability (mineral fertiliser equivalent) of organic fertilisers.

Long term S effect in field experiments

Long term application of organic fertilisers increases Corg content of surface soils (slurry 1.20 %, biocompost 1.51 and 1.64 %, control 1.15%) and consequently the S release potential. Enhanced S net mineralisation from manured soils reached its maximum in the end of June with 2-4 kg for slurry and biocompost (1x) and up to 8 kg S ha-1 for biocompost (2x) (Figure 4). In July S turnover is influenced by cultivation practise (irrigation of dry soil, harvest, straw manuring).

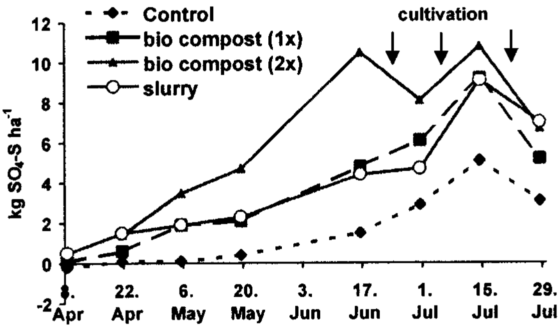

Figure 4. Net S mineralisation in surface soils after long term application (since 1980) of slurry and biocompost. Field measurements March - July 1999, fallow covered with foil.

Discussion

Short term S availability of organic fertilisers in incubation and pot experiments confirm the results of Eriksen *et al.* (1995) for slurry and Tabatabai and Chae (1991) for sewage sludge (pot experiments) and Janzen and Ellert (1998) in field. The outstanding effect of urine is based on its high SO42- content. S utilisation from sewage sludge is thought to be due to the high total S content, resulting from the treatment of sewage sludge with SO42- containing precipitants. There is a significant negative relationship between the short term S fertilisation effect and the C/S ratio of organic fertilisers. The critical C/S ratio for net S mineralisation of about 80, which can be deduced from the regression in Figure 3, is in agreement with results of Janzen and Ellert (1998).

The long term S availability is defined as net S mineralisation within one year and is controlled by the soil organic substance enriched S pool. S release from this source occurs in a later stage of the vegetation period (June/July) when soil temperature increases. This S release is to be considered in the S balance of agricultural crop management.

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