SIGNIFICANCE OF SOIL WATER DYNAMICS FOR THE SULPHUR BALANCE OF OILSEED RAPE

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ABSTRACT

Recently severe sulphur (S) deficiency became one of the most widespread nutrient disorders in North-European agriculture. For the prognosis of plant available S, soil analysis would be an ideal method, however, no relation between plant and soil S concentrations could be established. The reasons for the impracticability of traditional soil tests seem to be related to interactions between soil water and mobile S in soils, so that a site specific model needs to be developed for the prognosis of the S status of agricultural crops.

INTRODUCTION

Oilseed rape is an agricultural crop with a high demand for S because of the high protein content in its seeds and also the characteristic presence of S containing glucosinolates. As natural atmospherical deposition contributes in only a small way to the total S balance a sufficient S supply requires fertilisation that takes not only crop demand but also physical soil parameters into account. Soil analysis for the prediction of the S supply under field conditions fails because plant available soil S concentrations do not reflect the nutritional status of the plant. In contrast physical soil parameters together with the soil water regime and crop specific attributes seem to be decisive for the S supply.

RESULTS AND DISCUSSION

Atmospherical S deposition declined in the last 15 years by more than 50% and amounts to less than 15 kg ha^{-1} yr^{-1} S in Northern Germany. In contrast the S demand of oilseed rape is about 70 - 90 kg ha^{-1} yr^{-1} S resulting in a strong discrepancy between natural supply and requirement. Other factors contributing to severe S deficiency are a reduction in the use of S containing fertilisers and increased crop yield with corresponding increased S uptake.

The problem for the quantification of the S status is the high mobility of sulphate (SO_4-S) in soil which is affected by precipitation, evapotranspiration and lateral fluxes. Until start of stem extension leaching of SO_4-S is the predominant process thus determining the initial basis of S supply. Within the maximum growth stage from stem elongation to flowering, however, capillary rise and ascending water are more influential. Most soils represent open systems where SO_4-S losses (due to leaching) and enrichments (through capillary rise) cause an important variation in the S supply so that simple soil tests for S fail to give a representative evaluation of the nutritional status. In adition timing of sampling will play an important role, but even if soil samples are taken at a favoured time namely in the period of the highest S demand, no improvement of the expressiveness of the data could be observed (Haneklaus et al., 1995). The reasons for the impracticability of common soil tests relate to the depth of sampling (0 - 30 cm), because only a fraction of the real plant available amount of S, which varies in dependence on root depth and density, is included and the fact that SO_4-S concentrations are not static but variable within soil profile and time.

Mineralisation within the growing period has been considered as a major S pool (Blair et al., 1991), however recent research work reveals that this factor has been overestimated (Eriksen, 1995); moreover it seems as if equilibrium is reached between mineralisation and immobilisation in soil.

The calculation of S balances is further complicated by S removal which varies according to crop and yield level. Furthermore, leaching of SO_4-S is affected by annual precipitation and soil water suction. As groundwater is a storage pool for SO_4-S with medium concentrations of 50 mg l^{-1}, capillary rise will strongly influence the S supply on soils where plants have access to this S source.

In Table 1 the influence of water dynamics in soils with different texture on the S supply of oilseed rape is calculated. The annual atmospheric S deposition has been assumed with an upper value of 30 kg ha^{-1} yr^{-1}, the SO_4-S concentration in groundwater with a lower value of 10 mg l^{-1} (Table 1). Data concenring root space, plant available water and others derive from literaure (Geisler, 1980; Schroeder, 1978).

TABLE 1. Quantification of the effect of physical soil parameters and water balance on the S supply of oilseed rape

Soil texture	**Loamy sand**	**Sandy loam**	**Clayey loam**
Groundwater level: 1.20 m			
Period	July - February		
Precipitation (mm)	531 [20 kg ha^{-1} S]	531 [20 kg ha^{-1} S]	531 [20 kg ha^{-1} S]
Evaporation (mm)	344	344	344
P - E (mm)	187 [20 kg ha^{-1} S]	187 [20 kg ha^{-1} S]	187 [20 kg ha^{-1} S]
Effective root zone (cm)	70	90	100
Plant available water (mm)	115 [12 kg ha^{-1} S]	155 [17 kg ha^{-1} S]	165 [18 kg ha^{-1} S]
Percolating water (mm)	72 [8 kg ha^{-1} S]	32 [3 kg ha^{-1} S]	22 [2 kg ha^{-1} S]
Period	March - February		
Precipitation (mm)	302 [10 kg ha^{-1} S]	302 [10 kg ha^{-1} S]	302 [10 kg ha^{-1} S]
Evaporation (mm)	240	240	240
P - E (mm)	62 [10 kg ha^{-1} S]	62 [10 kg ha^{-1} S]	62 [10 kg ha^{-1} S]
Plant available water (mm)	115 [12 kg ha^{-1} S]	155 [17 kg ha^{-1} S]	165 [18 kg ha^{-1} S]
Supply (mm)	177 [22 kg ha^{-1} S]	217 [27 kg ha^{-1} S]	227 [28 kg ha^{-1} S]
Transpiration coefficient: 650 l kg^{-1} dm transpiration sum for 4 t ha^{-1} yield: 260 mm			
Water deficit (mm)	198	198	198
Capillary rise (mm day^{-1})	5	5	5
Time (days) for capillary rise of groundwater into root zone	100	60	< 40
Plant available S (kg ha^{-1})	**≈ 22**	**≈ 27**	**≈ 50**

If the total water deficit could be balanced with groundwater an additional S supply of 22 kg ha^{-1} could be verified even if the SO_4-S concentration is low (10 mg l^{-1}). The data presented in Table 1 reveal that under the chosen conditions the natural S supply would not be sufficient to fully compensate for the S demand of oilseed rape so that S fertilisation is necessary. However, with a SO_4-S concentration in the groundwater of 40 mg l^{-1} the S requirements of the crop would be satisfied with about 105 kg ha^{-1} S.

The seasonally dependent water dynamics reveal the significance of soil texture and capillarity, groundwater level and transpiration rate for the S supply of agricultural crops. Therefore light porous soils with limited access to the groundwater are the most sensitive towards S deficiency and hampered root growth due to adverse soil properties will strengthen the problem.

MOPS - a new Model for the Prognosis of the Sulphur-status takes relevant soil, plant and atmospherical properties into account in order to evaluate the S nutritional status and fertiliser requirements of agricultural crops. *MOPS* is a dynamic model which integrates precipitation and evapotranspiration curves for different types of crop rotation into the soil water regime of different soil types. Therefore the verification of *MOPS* requires the establishment of continuous space-time relationships for all integrated parameters. With *MOPS* not only a reliable prognosis model but also an efficient tool for optimised fertiliser strategies will be available.

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