

Nitrogen and sulfur fertilization for a Signal grass pasture: forage yield, nutritional status and some soil fertility attributes in a rainy season

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Abstract

Fertilizer application is required for pasture establishment and productivity, and the sulfur supply is not always considered when grasses are fertilized with nitrogen. The objectives were to evaluate the effects of combined nitrogen and sulfur rates in a degrading Signal grass (*Brachiaria decumbens*) pasture during a rainy season, by measuring forage yield, nitrogen and sulfur concentrations, N:S ratio and SPAD values in the diagnostic leaves, and some soil fertility attributes. The experiment was carried out on an eight years old Signal grass pasture, which was established on an Entisol. Five nitrogen rates and five sulfur rates were combined in a 5x5 fractionated factorial, in a randomized block design, with three replications. Nitrogen and sulfur combinations resulted in significant changes in the Signal grass productivity and SPAD values in the grass during the rainy season. Both nitrogen and sulfur concentrations in the diagnostic leaves were increased by nitrogen and sulfur rates, respectively. Sulfur deficiency was found in the diagnostic leaves of the grass that did not receive sulfur fertilizer. Nitrogen rates reduced soil pH and exchangeable potassium and magnesium, whereas exchangeable calcium did not change.

Key Words

Brachiaria decumbens; Forage grass; Leaf diagnosis; Pasture fertilization; SPAD.

Introduction

Lack of nutrients, inadequate management of pastures, and inappropriate cultural practices are responsible for pasture degradation. These inappropriate management practices can also result in severe environmental consequences, such as reduced soil fertility, decrease in water use efficiency, decline in plant biomass production, reduced soil coverage, decreased soil biological activity, and increased soil compaction and soil erosion (Syers *et al.* 1996). Low nitrogen availability has been identified as a major cause of degradation of tropical pastures (Werner 1994), and the constant removal of forage without proper supply of nutrients extracted by plants emphasizes the problems of rangeland degradation. The combined application of nitrogen with sulfur has proved to be effective in maximizing the leaf area and the production of dry matter of grasses, and the balance between the amounts of these two nutrients in the soil and the plant provides adequate growth and nutritional status of the plant (Dijkshoorn and van Wijk 1967; Bonfim-Silva and Monteiro 2006; Batista and Monteiro 2008). The objectives of this research were to determine the effects of nitrogen and sulfur rates on forage yield, mineral nutritional status and some soil fertility attributes, when applied to a degrading Signal grass pasture during a rainy season.

Methods

The experiment was carried out in a farm (47° 57' 56" W and 22° 46' 30" S) located at Piracicaba, State of São Paulo, Brazil, during the 2005-2006 wet season. A Signal grass (*Brachiaria decumbens* Stapf.) pasture was established over eight years on an Entisol, did not receive any previous fertilization and was degrading. The experimental area (1800 m²) was isolated from the farm pasture, and each plot was 5m x 8 m. Dolomitic limestone (600 kg/ha) was applied to the soil surface prior to any fertilization. Phosphorus (P₂O₅ = 30 kg/ha) was supplied as triple superphosphate, potassium (K₂O = 30 kg/ha) as potassium chloride, and micronutrients as FTE Br-16 (30 kg/ha). Five nitrogen rates (0, 150, 300, 450 and 600 kg/ha/yr) and five sulfur rates (0, 15, 30, 45 and 60 kg/ha/yr) were combined in a 5x5 fractionated factorial (Littell and Mott 1975), in a randomized block design with three replications. Nitrogen was supplied as ammonium nitrate and sulfur as gypsum, and both products were split into three times during the rainy season (November 17, 2005; December 23, 2005 and January 28, 2006). Forage yield was measured at predetermined intervals of 35 days during the rainy season, which resulted in five field evaluations (December, 2005; January, 2006; March, 2006; April, 2006 and May, 2006). At each evaluation time, samples of plant shoots were taken within a wood frame of 1.00 m x 0.25 m (0.25 m²) placed in each plot, and plants were harvested at 5 cm from the soil surface. At the time of the third field evaluation (March 01, 2006) SPAD values were measured in the

second fully expanded leaf lamina, and the first and second fully expanded leaf laminae (diagnostic leaves) were collected. All plots were grazed by beef cattle just after plant measurements and sampling. Plant samples (both above ground mass and the two fully expanded leaf laminae) were put in a paper bag, placed in an oven (65° C) to obtain constant dry weight, followed by weighing. The samples of fully expanded leaf laminae were ground and taken to the laboratory for nitrogen (Kjeldahl method) and sulfur (turbidimetric method) determinations. Also the N:S ratio in the leaf laminae samples was calculated. Soil samples were taken at depths 0-10 and 10-20 cm at the end of the rainy season. Soil determinations were pH in CaCl₂ and exchangeable K, Ca and Mg (after extraction by ion exchange resin). Statistics were performed through the use of the Statistical Analysis System (SAS 1999), and the significance level was 5% in all statistical tests. The analysis of variance (F test) was performed first, then, the RSREG procedure (for response surface) was used when the nitrogen x sulfur interaction was significant, and GLM procedure (for the first and second order regression models) was adopted when that interaction was not significant.

Results

Signal grass forage yield during the six-month wet season ranged from 13,447 to 25,142 kg/ha, depending on the nitrogen x sulfur interaction and the results fitted to a polynomial regression model (Figure 1). Such nitrogen x sulfur interaction was also observed by Bonfim-Silva and Monteiro (2006) for *Brachiaria decumbens*, Batista and Monteiro (2008) for *Brachiaria brizantha* cv. Marandu. In order to reach the highest forage yield it was necessary to supply nitrogen at 450 kg/ha/yr, associated with the higher sulfur rates (45 to 60 kg/ha/yr). No-nitrogen combined with no-sulfur resulted in about half the forage yield that was measured when both nutrients were supplied. The supply of sulfur, even proved to be necessary to increase forage yield, but only showed a clear beneficial effect when applied together with nitrogen. Also, Havlin *et al.* (2005) reported that an adequate supply of sulfur to the pasture increased the response of grasses to applied nitrogen and improved the efficiency of use of nitrogen. These results confirm the importance of balancing the supply of nitrogen and sulfur to achieve high productivity of grasses.

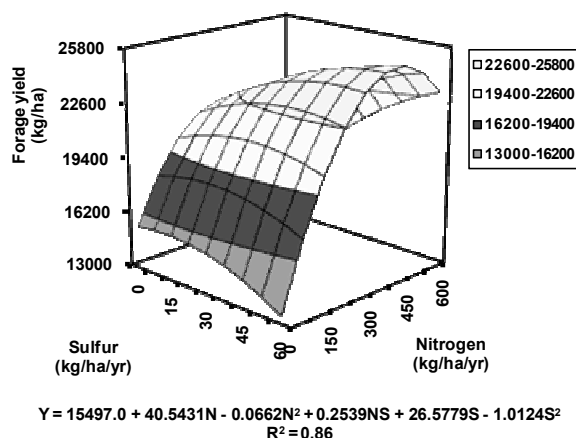


Figure 1. Signal grass forage yield in response to combined nitrogen and sulfur rates in the wet season.

The nitrogen x sulfur interaction was not significant for nitrogen and sulfur concentrations, and for N:S ratio in the diagnostic leaves of Signal grass collected at the third evaluation during the rainy season. However, nitrogen and sulfur concentrations in the diagnostic leaves were significantly changed by nitrogen and sulfur rates. Nitrogen concentration in the diagnostic leaves reached the maximum at the nitrogen rate of 462 kg/ha/yr (Figure 2a), whereas the maximum sulfur concentration occurred at the sulfur rate of 40 kg/ha/yr (Figure 2b). Both nitrogen and sulfur rates had significant linear effects on the N:S ratio in the grass diagnostic leaves (Figure 2c). Low sulfur concentration and high N: S ratio in diagnostic leaves supported the sulfur deficiency identification in the grass not fertilized with sulfur. Nitrogen x sulfur interaction was significant for the SPAD values measured in the expanded leaf laminae at the same time of diagnostic leaves sampling. Nitrogen supplied at 450 to 600 kg/ha/yr associated with sulfur application of 45 to 60 kg/ha/yr resulted in the maximum SPAD values (Figure 2d). The changes in the nitrogen and sulfur relationships have been described for other grasses (Wang *et al.* 2002; Gierus *et al.* 2005).

The nitrogen x sulfur interaction was not significant for the soil pH, and exchangeable Ca, Mg and K measured at the end of the wet season, but significance was found for the nitrogen rates on three of these four soil attributes. Soil pH values varied from 5.2 to 4.7 at a 0-10 cm depth (Figure 3a) and from 5.0 to 4.5 at the

10-20 cm depth (Figure 3b). The decrease in soil pH (which in this case was about 0.5 unit) with increasing nitrogen fertilization is a well-known consequence of hydrogen release when ammonium is applied to the soil (Havlin *et al.* 2005). Exchangeable Ca at 0-10 or 10-20 cm soil depth did not change significantly with the treatments. On the other hand, both exchangeable K (Figure 3c) and Mg (Figure 3d) were linearly reduced as the nitrogen rates were increased. These decreases in soil exchangeable K and Mg may be a result of their removal (and leaching) from the exchangeable sites in the soil through the action of ammonium ion and their higher extraction by plants with increased yield.

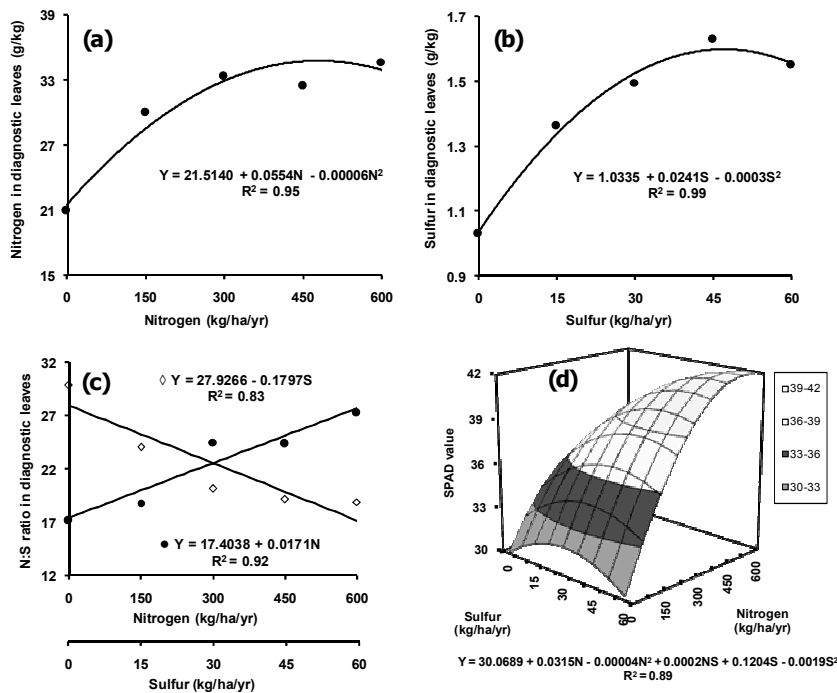


Figure 2. Nitrogen concentration (a), sulfur concentration (b), N:S ratio (c) and SPAD value (d) in the diagnostic leaves of Signal grass, as related to nitrogen and sulfur fertilization and determined at the third evaluation during the rainy season.

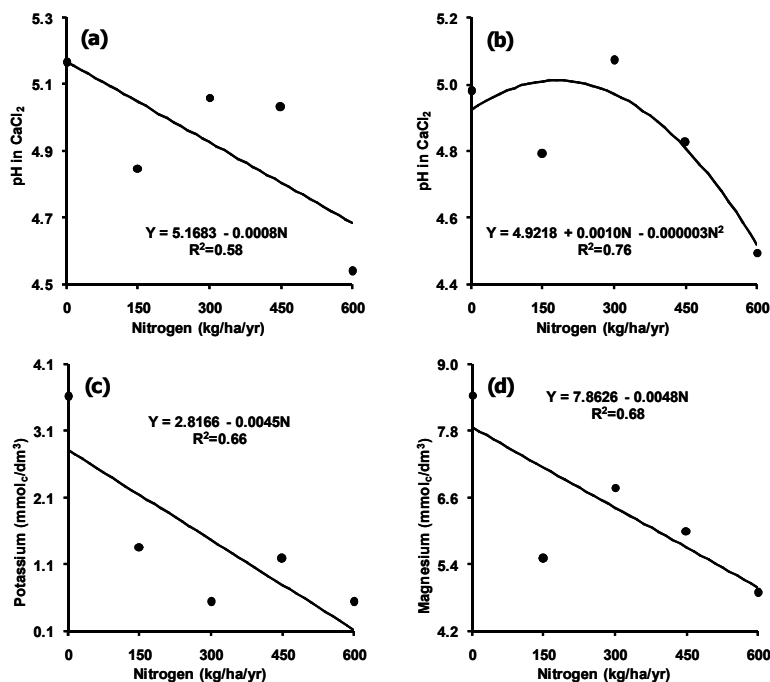


Figure 3. Soil pH at a depth of 0-10 cm (a), pH at a depth of 10-20 cm (b), potassium at a depth of 0-10 cm (c) and magnesium at a depth of 10-20 cm (d) from soil surface in the end of first rainy season of the experiment.

Conclusions

Nitrogen and sulfur combinations promoted the recovery of Signal grass productivity and changes in SPAD values during the rainy season. Nitrogen and sulfur fertilizations resulted in increases in these nutrients concentrations in diagnostic leaves. Sulfur deficiency was found in the grass that did not receive sulfur fertilization. Low depth soil pH and exchangeable potassium and magnesium were decreased by nitrogen fertilizations.

Acknowledgements

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References

- Batista K, Monteiro FA (2008) Nitrogen and sulphur on morphogenic characteristic of marandu palisadegrass replacing signal grass under degradation in a low organic matter soil *Brazilian Journal of Animal Science* **7**, 1151-1160.
- Bonfim-Silva EM, Monteiro FA (2006) Nitrogen and sulphur for productive characteristics of signal grass from degrading pasture area *Brazilian Journal of Animal Science* **4**, 1289-1297.
- Dijkshoorn W, van Wijk AL (1967) The sulfur requirements of plants as evidenced by the sulfur-nitrogen ratio in the organic matter: a review of published data. *Plant and Soil* **26**, 129-157.
- Gierus M, Jahns U, Wulfes R, Wiermann C, Taube F (2005) Forage quality and yield increments of intensive managed grassland in response to combined sulphur-nitrogen fertilization. *Acta Agriculturae Scandinavica. Section B-Soil and Plant Science* **55**, 264-274.
- Havlin JL, Tisdale SL, Beaton JD, Nelson WL (2005) 'Soil fertility and fertilizers: an introduction to nutrient management'. (New Jersey: Pearson Prentice Hall)
- Littell RC, Mott GO (1975) Computer assisted design and analysis of response surface experiments in agronomy. *Soil and Crop Society of Florida Proceedings* **34**, 94-97.
- Statistical Analysis System (1999) 'User's guide statistics: version 8.0 edition' (Cary)
- Syers JK, Lingard J, Pieri C, Ezcurra E, Faure G (1996) Sustainable land management for the semiarid and sub-humid tropics. *Ambio* **25**, 484-491.
- Wang S, Wang Y, Schnug E, Haneklaus S, Fleckenstein J (2002) Effects of nitrogen and sulphur fertilization on oats yield, quality and digestibility and nitrogen and sulphur metabolism of sheep in the Inner Mongolia Steppes of China. *Nutrient Cycling in Agroecosystems* **62**, 195-202.
- Werner JC (1994) Fertilization of *Brachiaria* spp. In 'Symposium on pasture management' (Eds AM Peixoto, JC Moura, VP Faria) pp. 209-266. (Piracicaba: FEALQ).