Marandu palisadegrass fertilized with nitrogen forms and sulphur rates: productive responses

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Abstract
In the present glasshouse work it was aimed to evaluate changes in the productive attributes of Marandu palisadegrass (*Brachiaria brizantha* cv. Marandu) in response to soil fertilization with nitrogen forms and sulphur rates. Soil fertilization treatments were the combination of four nitrogen forms (none, nitrate, ammonium+nitrate and ammonium) and four sulphur rates (none, 15, 30 and 45 mg/dm^3). Treatments were arranged in a randomized complete block design, with four replications. Marandu palisadegrass was grown for 33 d after the transplanting, at which time number of leaves and tillers, leaf area and shoot dry matter were assessed. The productive response of Marandu palisadegrass fertilized with nitrogen and sulphur was affected by the nitrogen form supplied. Nitrate as nitrogen source strongly influenced the leaf area and shoot dry matter production of the forage grass. In general, grass production responses to sulphur rates seem to be more pronounced when the plants were fertilized with nitrate as nitrogen source.

Key Words
Soil fertilization; *Brachiaria brizantha*; nitrate; ammonium; forage grass

Introduction
Plant production is a result of growth and development processes and depends on nutrient availability in terms of forms and content in the soil. Among the nutrients, nitrogen along with phosphorus and potassium are largely applied worldwide through fertilizers (FAO 2008). Positive effects of nitrogen on crop productivity are notorious, especially on graminaceous plants (Xia and Wan 2008). The benefits of nitrogen supply on plant production are not restricted by the amount of nitrogen added to the soil, but nitrogen forms (ammonium and nitrate) are very important in promoting changes in plant morphogenesis (Walch-Liu *et al.* 2000; Rahayu *et al.* 2005). In addition, the nitrogen effects on plant growth can be changed by the sulphur availability in soil (Kalmbacher *et al.* 2005; Salvagiotti, *et al.* 2009), and probably plant response to nitrogen and sulphur interaction may change according to the supply of nitrogen form and sulphur rates. Thus, the objective was to evaluate changes in the productive attributes of Marandu palisadegrass (*Brachiaria brizantha* cv. Marandu) in response to soil fertilization with nitrogen forms and sulphur rates.

Methods
The experiment was conducted in a greenhouse located at Piracicaba, São Paulo (22°43’S; 47°38’W), Brazil, using 3.6-L pots filled with 5.5 kg of dried soil. The soil was collected from the surface 0-20 cm layer of a sandy soil classified as Entisol, characterized by low soil organic matter (14 g/kg) and low sulfate content (3.5 g/kg). Soil fertilization treatments were the combination of four nitrogen forms (none, nitrate, ammonium+nitrate and ammonium) and four sulphur rates (none, 15, 30 and 45 mg/dm^3). Thus, the 16 treatments evaluated were: $N_0 – S_0$; $N_0 – S_{15}$; $N_0 – S_{30}$; $N_0 – S_{45}$; Nitrate - S_0; Nitrate - S_{15}; Nitrate - S_{30}; Nitrate – S_{45}; Ammonium - S_0; Ammonium - S_{15}; Ammonium - S_{30}; Ammonium – S_{45}; Ammonium nitrate – S_0; Ammonium nitrate – S_{15}; Ammonium nitrate – S_{30}; and Ammonium nitrate – S_{45}. Nitrogen forms were managed to apply nitrogen at 300 mg/dm^3. The ammonium-N to nitrate-N ratio in the treatment ammonium nitrate was 30:70%. The ammonium-containing treatments received 20% of the total nitrogen through the nitrification inhibitor dicyandiamide (DCD). Treatments were arranged in a randomized complete block design with four replications. Nitrogen and sulphur were provided by the analytical reagents: $Ca(NO_3)_2$; NH_4Cl; and $CaSO_4.2H_2O$.
Taking into consideration the nutritional requirements of Marandu palisadegrass, liming was done with the objective of increasing soil base saturation to 50% by the application of $CaCO_3$ and $MgCO_3$. Basal fertilization with macronutrients for the establishment of Marandu palisadegrass were: phosphorus (P) = 200 mg/dm^3; potassium (K) = 250 mg/dm^3 and magnesium (Mg) = 50 mg/dm^3, provided through KH_2PO_4, and $MgCl_2.6H_2O$. Additional amounts of calcium were applied as $CaCl_2.6H_2O$ to equilibrate that supplied by nitrogen and sulphur sources in all treatments. Micronutrients as boron, copper, zinc and molybdenum were

supplied before grass planting with the following sources and amounts: H_3BO_3 = 1.5 mg/dm^3; $CuCl_2.2H_2O$ = 2.5 mg/dm^3; $ZnCl_2$ = 2.0 mg/dm^3 and $Na_2MoO_4.2H_2O$ = 0.25 mg/dm^3.
Marandu palisadegrass seeds were germinated on a sterile sand medium. After 10 d, the seedlings were transferred to the soil in the pots (transplanting), and five grass plants were grown per pot. Irrigation was performed to maintain the soil water content around 80% of field capacity. Plant shoots were harvested 33 d after the transplanting. Plants were cut up to 4 cm above the soil and the above-ground material (shoot) was dried in a forced air oven at 65°C until constant mass. At the harvesting time, the number of tillers and leaves and leaf area of plants were also quantified. Leaf area was determined by using a leaf area machine model LI 3100 (LI-COR, NE, USA).

Results

The number of leaves of Marandu palisadegrass did not change with the supply of nitrogen and sulphur by soil fertilization (Figure 1a). On the other hand, the number of tillers was affected by nitrogen fertilization, in terms of quantity and nitrogen forms, and also by sulphur supply (Figure 1b). In general, increasing the sulphur availability to the plants resulted in more tillers produced.
The morphology of Marandu palisadegrass leaves was greatly influenced by the nitrogen forms used in soil fertilization (Figure 1c). Plants supplied with nitrate had a larger leaf area, enhancing the area of light interception (Akmal and Janssens 2004). Similar results have been reported by Walch-Liu *et al*. (2000) for tobacco plants grown in nutrient solution, where the authors found that leaves of plants treated with ammonium as nitrogen source presented 50% reduction in the number of cells and a 30% reduction in cell size, when compared with nitrate-fed tobacco plants.

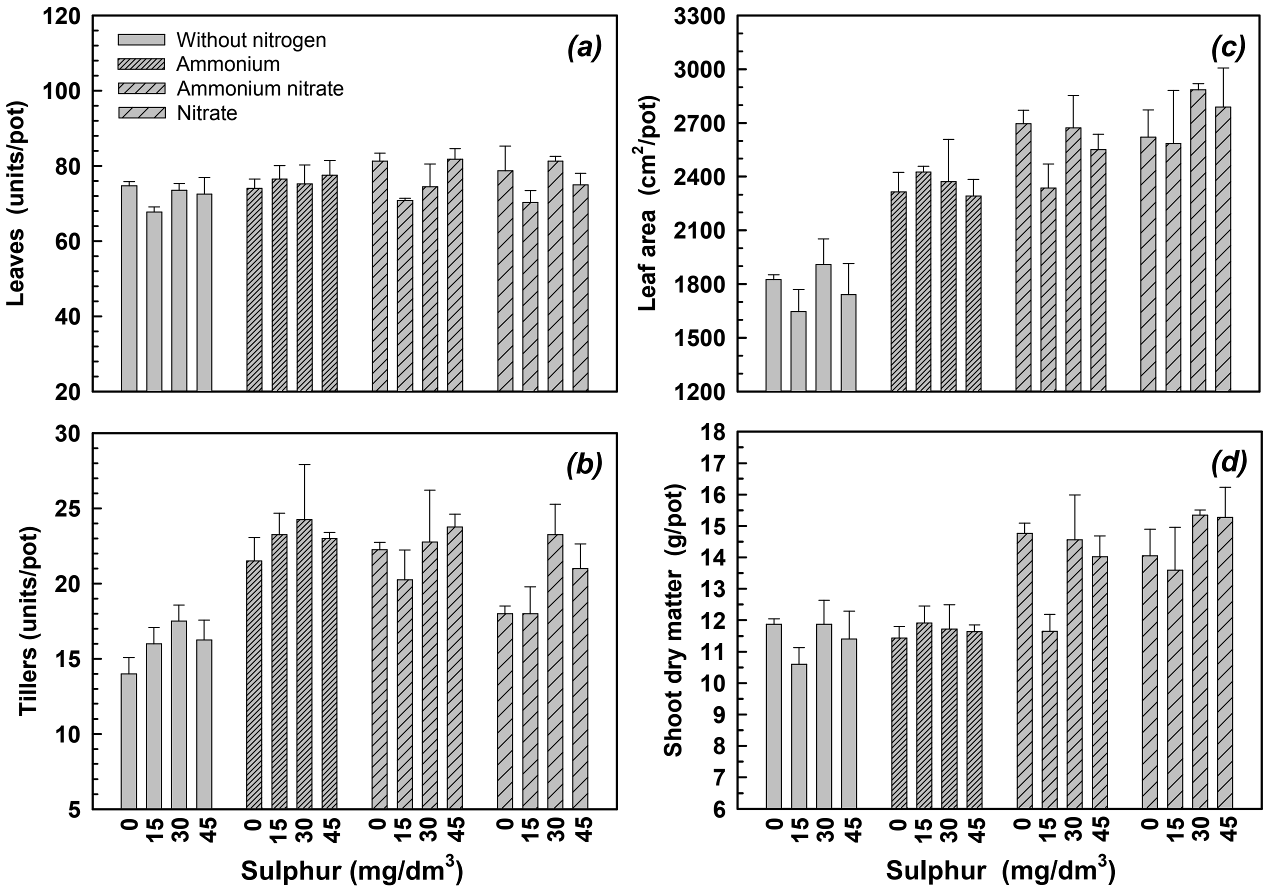

Figure 1. Leaves (*a*), tillers (*b*), leaf area (*c*) and shoot dry matter (*d*) production of Marandu palisadegrass fertilized with nitrogen forms and sulphur rates.

Conversely to the number of tillers and leaf area, the shoot dry matter production of Marandu palisadegrass was unaffected by the supply of nitrogen in the ammonium form (Figure 1d). Actually, only nitrogen as nitrate or ammonium mixed with nitrate showed increasing Marandu palisadegrass shoot dry matter. Possibly, plants growing in a medium with high ammonium availability may have impaired the shoot dry matter production through the effect of ammonium toxicity (Marschner 1995).
Comparing plants fed with ammonium or nitrate solely, it seems that the effects of additional sulphur are more pronounced when the forage plants were fed with nitrate as nitrogen source (Figure 1b, 1c and 1d). These results agree with previous studies (Migge *et al.* 2000; Prosser *et al.* 2001), which postulated that S-deprived plants fertilized with nitrate showed decreased nitrate reductase activity.

Conclusions

The productive response of Marandu palisadegrass fertilized with nitrogen and sulphur depends on the nitrogen form. Nitrate as nitrogen source is closely related to leaf area and shoot dry matter production. In general, grass production responses to sulphur rates seems to be more pronounced when the plants are fertilized with nitrate-containing fertilizers.

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