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Tolerance of *Urochloa brizantha* cv. MG5 to Mn Toxicity

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ABSTRACT

Available information of the effects of manganese nutrition on the forage genus *Urochloa* is scarce. In the context, this study aims to evaluate the tolerance of *Urochloa brizantha* cv. MG5 to Mn toxicity. The experiment was conducted in a greenhouse at the University of the State of Sao Paulo (UNESP) in the city of Jaboticabal, SP. Plants were cultivated in vases (3.5 L) filled with soil according to a completely randomized experimental design comprising of five levels of Mn (0, 15, 30, 60 and 120 mg·dm^{-3}) and four replications and cut in two periods: one is 42 days after sowing and the other is 30 days after the first one. Samples from both cuts were evaluated as to plant height, number of leaves and tillers, dry weight, Mn content and accumulation, and the green index was determined in the last cut. Manganese addition to soil caused an increase in chlorophyll content at the dosage of 68 mg·dm^{-3} observed in the second plant cut. Dosages of Mn above 15 mg·dm^{-3} did not induce increases in nutrient accumulation and in the number of leaves in the first and second cuts of the grass, and tillers in the first cut. The highest concentrations of manganese in the shoots did not produce visual symptoms of damage or a decrease in forage productivity demonstrating that *Urochloa brizantha* cv. MG5 has high tolerance to manganese toxicity.

Keywords: Forage; Pastures; Plant Nutrition; Soil Fertility; Micronutrient

1. Introduction

Forage plants in many cultivated areas in Brazil belong to the genus *Urochloa*, a good annual producer of biomass irrespective of the different climate conditions prevailing in the country. However, forage production in Brazil is limited by low fertility soils and inadequate agricultural practices leading to nutritional imbalance.

Increased availability of Al and Mn in the predominantly acid tropical soils, may lead to Mn toxicity as observed in mandaru grass (*Urochloa brizantha* cv. Mandaru) [1]. According to van Raij [2] in micronutrient soil fertilization care should be taken to keep Mn concentrations below the level of 1.5 mg·dm^{-3}.

Mn as a micronutrient has an important role in processes like ionic absorption, photosynthesis and respiration, hormonal control, protein synthesis, resistance to illness and protection against oxidative stress [3]. Adequate Mn concentrations in *Urochloa brizantha* plants should be around 40 to 250 mg·kg^{-1} [4].

Visual symptoms induced by low Mn in forage plants include reticulate chlorosis in new leaves, which may progress to foliar necrosis. On the other hand, high Mn concentrations produce symptoms on leaf surfaces as marginal chlorosis, brown punctuated stains evolving to necrosis and leaf wrinkling [5]. Concentrations of Mn higher than 1000 mg·kg^{-1} may also be toxic to animals [6].

Studies relating growth in forage plants to deficiencies, accumulation and toxicity effects of Mn are not common in the literature. The ones reported are restricted to forages as MG4 grass [7], Marandu grass [8], Mombaça grass [9] and Tanzania grass [10]. Cultures of rice, perennial rye grasses and white clover [11,12], *Juncus exulta* L. [13] and sugar cane [14] are addressed in other studies.

It is significant to know the effects of Mn on currently cultivated forage species like cv. MG5 that is widely cultivated in Brazil, since plant tolerance to high levels of the nutrient in soil is influenced by genotype. This report evaluates tolerance of *Urochloa brizantha* cv. MG5 to Mn toxicity.

2. Material and Methods

The experiments in this study were conducted in green houses at the Faculty of Agrarian and Veterinarian Sciences, State University of Sao Paulo (UNESP) in Jaboticabal, SP, Brazil, from August to October, 2011, utilizing the forage plant *Urochloa brizantha* cv. MG5.

Experimental units consisted of vases (3.5 dm^3) filled with dystrophic, medium texture Red Latosoil [15]. Soil samples collected from layers 0 - 20 cm deep in the experimental area were analysed by the method of van Raij *et al*. [16] with the following results: pH = 4.8; M.O. = 9 $g \cdot dm^{-3}$; P (resin) = 4 $mg \cdot dm^{-3}$; (H + Al) = 18 $mmol_c \cdot dm^{-3}$; K = 1.2 $mmol_c \cdot dm^{-3}$; Ca = 18.0 $mmol_c \cdot dm^{-3}$; Mg = 8.0 $mmol_c \cdot dm^{-3}$; SB = 27.2 $mmol_c \cdot dm^{-3}$; CTC = 45.2 $mmol_c \cdot dm^{-3}$; V = 60%; B = 0.11 $mg \cdot dm^{-3}$; Cu = 1.2 $mg \cdot dm^{-3}$; Fe = 5.0 $mg \cdot dm^{-3}$; Mn = 7.6 $mg \cdot dm^{-3}$; Zn = 0.2 $mg \cdot dm^{-3}$.

The experimental design was completely random with four repetitions. Treatments consisted of five dosages of Mn (0, 15, 30, 60 120 $mg \cdot dm^{-3}$) applied as manganese sulphate (35.5% Mn) to plants of *Urochloa brizantha* cv. MG4 as suggested by Puga *et al*. [7]. Each experimental unit received basic fertilization in the following dosages: K as (KCl p.a.) 200 $mg \cdot dm^{-3}$; Cu as ($CuSO_4 \cdot 5H_2O$ p.a.) 1.5 $mg \cdot dm^{-3}$; B as (H_3BO_3 p.a.) 0.8 $mg \cdot dm^{-3}$; Mo as ($NaMoO_4 \cdot 2H_2O$ p.a.) 0.15 $mg \cdot dm^{-3}$; Fe as [$Fe_2(SO_4)_3 \cdot 4H_2O$ p.a.] 4.0 $mg \cdot dm^{-3}$ and Zn as ($ZnSO_4$ p.a.) 5 $mg \cdot dm^{-3}$. P was added as plain superphosphate (305 $mg \cdot dm^{-3}$) and N as urea, in two periods, 100 $mg \cdot dm^{-3}$ during sowing and 50 $mg \cdot dm^{-3}$, 30 days after [17].

Mn dosages were incorporated into the soil before forage sowing. Ten days after emerging, plants were thinned out to 6 plants per vase. Irrigation with deionized water was by the weighing method, humidity corresponding to 60% of the retention capacity. Forty two days after sowing the culture plants were cut 10 cm above soil and 30 days after close to the soil. After cuts, plant height, number of leaves, number of tillers and aerial dry matter per vase were determined. The green color index was determined at the second cut using the CCM 200 device (Opti-Sciences) and considering the measurement at the median third of totally expanded leaves (5 per vase). Root dry matter was also evaluated at this period. To determine levels of Mn in plants, aerial parts from each vase were washed in distilled water, dried in a hot house with forced air circulation at 65˚C - 70˚C until constant weight, ground and submitted to chemical analysis according to the method proposed by Bataglia *et al*. [18]. Mn accumulation was calculated by relating nutrient concentration to dry weight.

Results were submitted to analysis of variance by the F test ($P < 0.05$) and to regression analysis utilizing the SISVAR statistical Program [19]. Component coefficients in each model were tested and the ones with the highest determination coefficients were chosen.

3. Results and Discussion

Soil fertilization with dosages of Mn resulted in an increase of the leaf green color index with quadratic adjustments when determined in plants of the second cut, a maximum value attained when the nutrient dosage was 68 $mg \cdot dm^{-3}$ (**Figure 1(a)**). The increase in the index is due to the role of Mn in the structure, function and multiplication of chloroplasts [3]. With dosages higher than 68 $mg \cdot dm^{-3}$ chlorophyll decrease may be due to competition for the nutrient, an important factor in the synthesis of the heme group in the pigment's structure [20]. It is also possible that at higher Mn concentrations, the decreased green index is due to toxic effects, apparent later when plants are already highly damaged [21].

Determination of Mn concentrations in forage aerial parts at the first cut showed a maximum increase (282.3 $mg \cdot kg^{-1}$) at the nutrient dosage of 30 $mg \cdot dm^{-3}$ (**Figure 1(b)**). The value is in contrast to the values of 40 to 250 $mg \cdot kg^{-1}$ considered by Silva [4] to be adequate for *Urochloa brizantha* and of 40 to 200 $mg \cdot kg^{-1}$ for forage grasses (group II) according to Raij *et al*. [2]. However, concentrations of 80 to 300 $mg \cdot kg^{-1}$ are considered adequate for aerial parts of forages in general by Malavolta [22]. The wide range of values, characterizing a variety of forages is perhaps justified since cultivars are not specified.

Variations in Mn content are due to differences in species, soil and climate condition of cultures, factors that affect the nutritional state of plants [23]. At the second cut in this study, plants did not show significant effects of the different additions of Mn to the soil (F = 2.19 ns) (**Figure 1(b)**).

It should be noted that there are reports of higher Mn values using the same treatments in Marandu grass [8], *Urochloa brizantha* cv. MG4 [7], and Tanzania grass [10]. The discrepancies are probably due to different procedures in incorporating the nutrient. In the present study the Mn salt was mixed with the whole bulk of soil in each vase, while in the cited reopiorts application was localized. By this method losses by adsorption to the soil are decreased and plant absorption is increased.

Symptoms of excessive nutrient concentrations at the dosages applied were not detected neither in this study nor in the reports for Marandu grass [8], *Urochloa brizantha* cv. MG4 [7] and Mombaça grass [9] with an exception for Tanzania grass [10]. The species probably has a higher foliar tolerance to the nutrient [24].

As shown in **Figure 1(c)**, dosages of Mn applied to the soil produced accumulation of nutrients in the plant aerial parts. The dosage of 15 $mg \cdot dm^{-3}$ produced increments of 0.97 and 1.4 $mg \cdot vase^{-1}$ in both cuts, respectively, in accumulated concentrations. The higher value in the second cut was possibly due to the additional N fertilization (urea), which lowered soil pH by liberating

H^+ during nitrification and the resulting increased Mn availability [25].

Mn added to the soil, promoted an increase in the number of leaves attaining a maximum of 37 and 45 leaves $vase^{-1}$, in the first and second cuts, respectively, when addition was of 15 $mg \cdot dm^{-3}$ (**Figure 2(a)**).

Number of tillers per vase was affected by Mn addition to the soil only at the first cut, showing a maximum of 15.6 tillers $vase^{-1}$ at the nutrient dosage of 15 $mg \cdot dm^{-3}$. The effect was not significant at the second cut (F = 1.62 ns). Mn application did not affect plant height both in the first (F = 1.46 ns) and the second cuts of forage plants (F = 0.51 ns) (**Figure 2(b)**).

Dry matter in plant aerial parts was only affected by Mn fertilization at the second cut. The maximum total (second cut) amount was 10 $g \cdot vase^{-1}$ at the dosage of 15 $mg \cdot dm^{-3}$ and 14 $g \cdot vase^{-1}$ as a sum of dry matter in both cuts (**Figure 2(c)**). This result possibly shows a delaying effect of Mn on the growth of *Urochloa brizantha* cv. MG5, which influenced the total production in the two cuts. Application of Mn to the soil did not affect root dry matter in both cuts (F = 1.73 ns at the first cut and F = 2.04 ns at the second cut). This result together with the one concerning plant aerial dry matter indicates absence of toxic effects, since it was expected that the radicular system could be affected hindering plant growth.

The absence of toxicity signs may be due to sequestering of Mn in plant vacuoles and, thus, a decreased influence in plant metabolism [26]. The results confirm high resistance to toxicity in this forage plant since nutrient accumulation per plant (**Figure 1(c)**) did not affect production of dry matter (**Figure 2(c)**). Furthermore, it probably shows that tolerance to Mn fitotoxicity is distinct and specific to genotypes.

4. Conclusion

Mn applied to soil increased the green color index, the accumulation of the nutrient per plant and the number of leaves and tillers $vase^{-1}$ in an experimental study with *Urochloa brizantha* cv. MG5. Maximal production of dry matter in plant aerial parts $vase^{-1}$ was observed with a

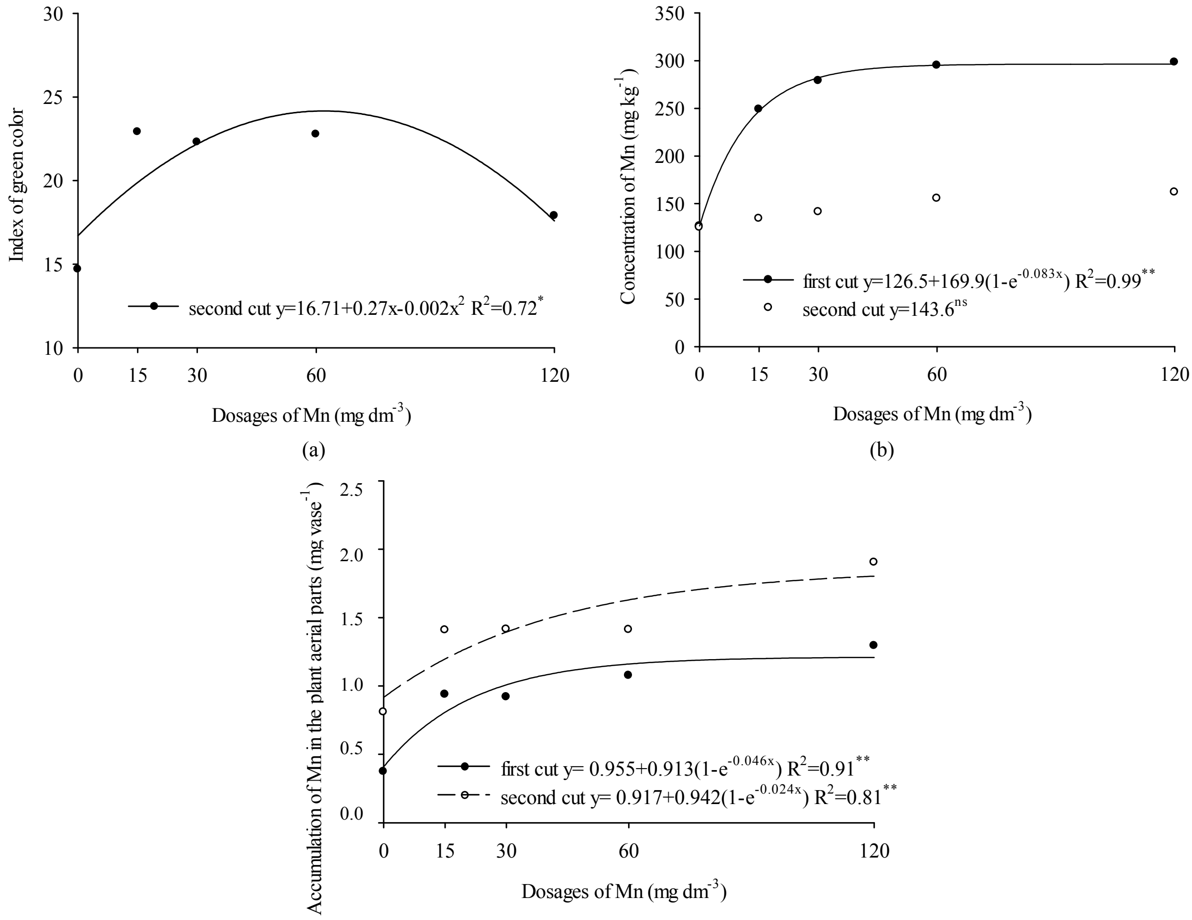

Figure 1. Green color index (a), Mn concentration (b) and accumulation of the nutrient (c) in the aerial parts of *Urochloa brizantha* cv. MG5 determined at the first and second cuts as a function of Mn dosages applied to the soil. ^{ns}Not significant by the F test; **, *Significant in the F test with probabilities lower than 0.01 and 0.05, respectively.

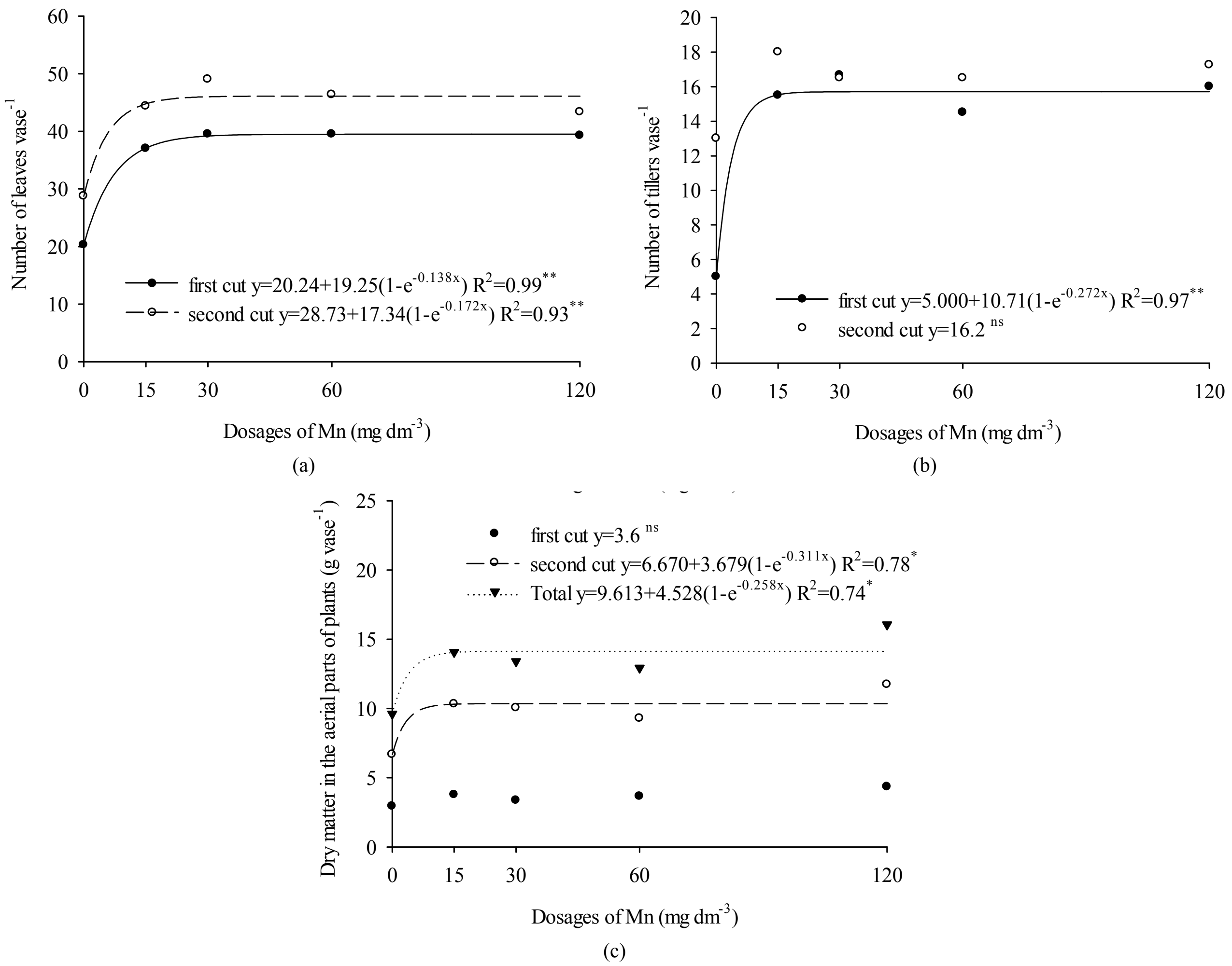

Figure 2. Number of leaves (a), numbers of tillers (b) and dry matter in aerial parts (c) of *Urochloa brizantha* cv. MG5 determined after the first and second cuts as a function of Mn dosages applied to the soil. Total dry matter (first and second cuts) also shown in (c). ^{ns}Not significant by the F test; **, *Significant by test F with a probability lower than 0.01 and 0.05, respectively.

Mn dosage of 15 mg·dm^{-3}. The high concentration of Mn in the plant aerial parts (282.3 mg·Kg^{-1}) did not induce toxicity visual symptoms or reduced forage productivity.

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