Recuperação de pastagem de *Urochloa decumbens* com sistemas de manejo e adubação fosfatada

*Urochloa decumbens* pasture recovery with management systems and phosphate fertilization

Recuperación de pasto de *Urochloa decumbens* con sistemas de manejo y fertilización de fosfato

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Resumo
O manejo adequado das pastagens é importante para garantir a produção animal. O objetivo deste estudo foi avaliar a produção massa seca da parte aérea (SDWY) e na composição mineral na recuperação de pastagens degradadas (*Urochloa decumbens*) em um Latossolo Típico com introdução de *Stylosanthes* e fertilização com fósforo (P). O delineamento experimental foi em blocos casualizados, em arranjo de parcelas subdivididas, com quatro repetições. As parcelas foram constituídas de sete sistemas de manejo: T1 - Controle *Urochloa decumbens* sem *Stylosanthes*; T2 - *U. decumbens* + *Stylosanthes* com plantio direto; T3 - *U. decumbens* com dessecação parcial + *Stylosanthes*; T4 - *U. decumbens* com dessecação total + *Stylosanthes*; T5 - *U. decumbens* + *Stylosanthes* com escarificação do solo; T6 - *U. decumbens* + *Stylosanthes* com aração; T7 - *U. decumbens* + *Stylosanthes* com lavoura + grade e as subparcelas foram as adubações com P (presença e ausência). A adubação com P (60 kg ha\(^{-1}\) de P\(_2\)O\(_5\)) aumentou a concentração de P e SDWY de *U. decumbens*, enquanto a introdução de *Stylosanthes* nos diferentes sistemas de manejo utilizados não alterou o produção de forragem.

Palavras-chave: Pastagem degradada; *Stylosanthes* spp.; *Urochloa decumbens*; solo tropical.

Abstract
Adequate pasture management is important to ensure animal production. The objective of this study was to evaluate the effect on shoot dry weight yield (SDWY) and mineral composition in degraded pasture (*Urochloa decumbens*) recovery in a Typic Oxisol with introduction of *Stylosanthes* and phosphorus (P) fertilization. The experiment was set up as completely randomized block design in a split-plot arrangement with four replicates. The plots were
seven management system: T1 - Control Urochloa decumbens without Stylosanthes; T2 - U. decumbens + Stylosanthes with no-till; T3 - U. decumbens with partial desiccation + Stylosanthes; T4 - U. decumbens with total desiccation + Stylosanthes; T5 - U. decumbens + Stylosanthes with soil scarification; T6 - U. decumbens + Stylosanthes with plowing; T7 - U. decumbens + Stylosanthes with plowing + harrowing and the subplots was the P fertilization (presence and absence). P fertilization (60 kg ha⁻¹ of P₂O₅) increased the P concentration and SDWY of U. decumbens, while the introduction of Stylosanthes in the different management systems used did not change the forage yield.

Index terms: Pasture degradation; Stylosanthes spp.; Urochloa decumbens; tropical soil.

1. Introduction

Soil inadequate management with fertilization absence and the exhaustion of natural soil fertility have been identified as one of causes of the degradation of cultivated pastures (Costa et al. 2009). In these conditions occur mainly due to soil organic matter (SOM)
reduction, in addition to nutrients losses such as P, potassium (K), calcium (Ca) and magnesium (Mg) (Schaefer et al. 2002). To recovery degraded areas can be adapted various strategies. Including management systems that reduce or null mechanical soil stirring, perennial crop system with high biomass yield and well developed root system, favoring the SOM accumulation, improving the biological activity and availability of nutrients in the soil (Tan et al. 2007).

The adoption of practices such as grass and legume intercropping can be an alternative for restoring or increasing soil fertility (Silva and Saliba 2007), as the legumes present great environmental and economic potential for their ability to nitrogen (N) fixation in the soil, maintaining pasture more productivity and providing the yield systems sustainability at reduced cost (Werner et al. 2001; Moreira, Malavolta, and Moraes 2002).

Another problem is the low available P content in weathered soils as it is found in Brazil's edaphoclimatic conditions. P fertilization plays an essential role in root development and grasses tillering (Fageria et al. 2013a), being related to the plant energy metabolism in all metabolic cycles related to energy expenditure (Fageria et al. 2013b). The P absence limits yield capacity, establishment and pastures persistence, as well as impairs the other nutrients uptake (Werner et al. 2001; Heinrichs and Soares Filho 2014).

The structural and productive characteristics of forage plants are benefited by phosphate fertilization (Melo, 2016; Pietramale, et al., 2020). Based on these responses, it is possible to establish management strategies associated with the phosphorus application in pasture recovery.

The objective of this study was to evaluate the degraded pasture recovery of Urochloa decumbens with introduction of Stylosanthes and P fertilization on the shoot dry weight (SDW) yield, macronutrient (N, P, K, Ca, Mg, and S) concentration and soil chemical properties.

2. Methodology

A field experiment was carried out in an Urochloa decumbens area with 10 years of grazing, which had low forage yield, with little invasive plants infestation, without soil compaction. The experimental area was located in Dracena County, São Paulo State, Brazil at 379 m altitude, latitude 20°55' S and longitude 51°23' W. According to the Koppen classification, the climate is type Aw, characterized by hot and humid summer seasons, warm, and dry winter, with a higher rainfall index between November and March. The annual
temperature and precipitation are respectively 23°C and 1,300 mm, and the climatic data for precipitation (mm), minimum average temperatures and maximum averages for the experimental period are presented in Figure 1.

The soil was classified as a Typic Oxisol (Santos 2013). Before of experiment, soil samples were collected at 0 – 0.2 m depth, presenting the following chemical and physical attributes: pH (CaCl₂ 0.1 mol L⁻¹) = 4.5, soil organic matter (SOM) = 21.5 g kg⁻¹, available P (resin) = 3.5 mg kg⁻¹, sulfur (S-SO₄²⁻) = 11.0 mg kg⁻¹; K⁺ = 4.6 mmolₖ g⁻¹; calcium (Ca²⁺) = 18 mmolₖ kg⁻¹, magnesium (Mg²⁺) = 7.5 mmolₖ kg⁻¹; cation exchange capacity (CEC) = 53.6 mmolₖ kg⁻¹, base saturation (V) = 56%, boron (B, hot water) = 0.9 mg kg⁻¹, copper (Cu, DTPA-TEA) = 0.8 mg kg⁻¹, iron (Fe, DTPA-TEA) – 53.0 mg kg⁻¹, manganese (Mn, DTPA-TEA) = 13.3 mg kg⁻¹, zinc (Zn, DTPA-TEA) = 1.2 mg kg⁻¹, sodium (Na) = 10.35 mg kg⁻¹, clay = 170 g kg⁻¹ and sand = 770 g kg⁻¹.

**Figure 1.** Precipitation and minimum and maximum temperatures during the experimental period. Source: CIIAGRO (2016).

The experiment was set up as completely randomized block design in a split-plot arrangement with four replicates. The plots were composed of seven management system: T₁
- Control (Urochloa decumbens without Stylosanthes), T2 - U. decumbens + Stylosanthes with no-till, T3 - U. decumbens with partial desiccation applying 1.5 L ha⁻¹ of the glyphosate active ingredient + Stylosanthes, T4 - U. decumbens with total desiccation applying 3.0 L ha⁻¹ of the active ingredient + Stylosanthes, T5 - U. decumbens + Stylosanthes with soil scarification, T6 - U. decumbens + Stylosanthes with plowing, and T7 - U. decumbens + Stylosanthes with plowing + harrowing. In the subplots was the P fertilization (60 kg ha⁻¹ of P₂O₅) and without P application.

The P source used was the simple superphosphate (20% P₂O₅), applied annually at the beginning of the rainy season. The plots were sized at 10 m × 10 m and the subplots 5 m × 10 m. The legume seeds sowing density was 5 kg ha⁻¹, with 92% cultural value. The distribution was the haul in the treatments T6 and T7, and the other treatments were in rows spaced 0.22 m. Due to the low Stylosanthes spp. availability in area, in November of 2015 a haul with density 3.0 kg ha⁻¹ of seed was carried out in all parcels except in the control. The soil samples for chemical properties were collected in 0.0-0.1 m and 0.1-0.2 m depth of in each subplot and the available P, K⁺, Ca²⁺, and Mg²⁺ were evaluated by the ion exchange resin method (Raij et al. 2001).

The evaluation of the forage yield was divided into two productive cycles: i) October to March - without hydric deficit), in which four cuts were made, and ii) April to June – with hydric deficit, corresponding to the dry period, one cut was made. The shoot dry weight (SDW) yield was measured from the forage harvest in 0.5 m² (1.0 m × 0.5 m), in each plot, when the plants of the best plots reached on average approximately 30 cm in height. The forage cut was at 10 cm of soil height to obtain the shoot fresh weight (SFW) in the following dates: 10/19/2015, 11/30/2015, 01/20/2016, 03/15/2016, and 06/22/2016. The samples were oven dried with forced air circulation at 65°C until constant weight (Silva and Queiroz 2002). The rearing of grass in experimental area was performed after sampling in a grazing system with heifers until reaching the residue around 10 cm in height. Forage of the third and fifth cuttings was used for macronutrients analysis (N, P, K, Ca, Mg, and S), the two cuttings being representative, respectively. The forage after drying was ground in a Willey mill, and then the acid digestions [sulfuric acid (N) or nitric-perchloric acid (P, K, Ca, Mg, and S)] were performed as described by Malavolta, Vitti, and Oliveira 1997).

The results were tested for errors normality, variance homogeneity and statistical analyzes (Shapiro and Wilk 1965). The results were submitted to ANOVA, F test and Scott-Knott's test for multiple means comparison at 5% significance.
3. Results and Discussion

The P, K⁺, Ca²⁺ and Mg²⁺ levels in the soil, in the 0.0-0.1 m and 0.1-0.2 m depth showed a significant interaction between soil management strategies × P fertilization (Table 1). The P fertilization performed annually for four years, since 2011, provided P accumulation, mainly in the 0.0-0.1 m depth, presenting higher values to the treatments without fertilization. These results showed that soil fertility can be constructed under pasture conditions and corroborate Sansonowicz, Lobato, and Goedert (1987) on the positive effect of P application on the increase of soil fertility. Due to the pasture fertilization being superficial, the available P concentration was higher in the 0.0-0.1 m compared to 0.1-0.2 m depth. However, it is possible to observe that in the deeper layer there was also an increase in the P concentration, which shows that, although slow, there is the nutrient movement in the soil profile. Another factor that should be highlighted in pasture conditions is that there is no soil rotation, which reduces P fixation, as well as soil erosion rate is also lower relative to annual crop systems (Santos et al. 2008). Regarding the soil management strategies, the lowest P levels were in scarification and plowing + harrowing, which may be involved with greater soil movement with these agricultural operations and promote nutrient fixation (Cubilla et al. 2007).

Even in the management systems without P fertilization, there was an increase in P levels in relation to the initial soil chemical analysis (3.5 mg kg⁻¹), value inside the same interpretation range indicated as low in the soil (Raij et al. 1996). These results can be attributed to the increase of SOM mineralization during the experimental period (Ferreira et al. 2014). The exchangeable K in 0.0-0.1 m and 0.1-0.2 m depth, although showing statistical variation, the results are very close to the effects of soil availability (Table 1). All values of this study are in the range of critical level from low to medium availability (Raij et al. 1996). It was possible to verify that the K concentration was lower than those found at time of experiment installation, even with annual nutrient application, according to recommendation described by Werner et al. (1997). Possibly, it attributed to the fact the large amount required by the forage plants, as well as being a nutrient that is readily available in the soil to absorb the plant and be quite mobile in the soil, facilitating leaching, especially in soils with medium texture (Heinrichs and Soares Filho 2014).
Table 1. Soil organic matter (SOM), phosphorus (P), potassium (K\(^+\)), calcium (Ca\(^{2+}\)), and magnesium (Mg\(^{2+}\)) concentrations of different soil depths in *Urochloa decumbens* in different soil management system and with or without P fertilization.

| Treatment | Soil management | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
|-----------|----------------|----|----|----|----|----|----|----|
| Without P | SOM (g kg\(^{-1}\)) | 15.0 | 17.0 | 16.3 | 18.5 | 18.5 | 17.3 | 15.3 |
| With P    | 16.5 | 16.0 | 16.5 | 17.0 | 15.8 | 15.0 | 13.5 |
| CV (%)    | 19.6 |     |     |     |     |     |     |     |
| Without P | P (mg kg\(^{-1}\)) | 5.0b | 7.5b | 7.0b | 6.5b | 5.0b | 7.5b | 7.0b |
| With P    | 26.5Aa | 24.0Aa | 24.5Aa | 27.5Aa | 21.0Ba | 25.0Aa | 18.5Ba |
| CV (%)    | 18.2 |     |     |     |     |     |     |     |
| Without P | K (mmol kg\(^{-1}\)) | 1.5Ba | 0.9Db | 1.7Aa | 1.5 B | 1.2 Cb | 1.3 Cb | 1.7A |
| With P    | 1.3Bb | 1.2Ba | 1.0Bb | 1.5 A | 1.4 Aa | 1.7 Aa | 1.6A |
| CV (%)    | 9.9 |     |     |     |     |     |     |     |
| Without P | Ca (mmol kg\(^{-1}\)) | 10.5Cb | 14.0Ab | 9.5Cb | 12.5Bb | 11.5Bb | 12.0B | 9.5C |
| With P    | 17.5Aa | 16.5Aa | 12.5Ca | 15.5Ba | 15.0Bb | 12.0C | 8.5D |
| CV (%)    | 9.5 |     |     |     |     |     |     |     |
| Without P | Mg (mmol kg\(^{-1}\)) | 7.0Cb | 11.5Aa | 9.0B | 9.5B | 8.0Cb | 10.0B | 7.5C |
| With P    | 12.0Aa | 12.5Aa | 7.5C | 9.0C | 10.5Ba | 9.5C | 8.0C |
| CV (%)    | 11.6 |     |     |     |     |     |     |     |
| Without P | Mg (mmol kg\(^{-1}\)) | 5.5Ca | 9.5Aa | 6.0Ca | 8.0Ba | 6.5C | 5.5C | 4.5D |
| With P    | 3.5Cb | 6.5Ab | 4.0Cb | 3.0Cb | 5.5B | 5.0B | 3.5C |
| CV (%)    | 19.0 |     |     |     |     |     |     |     |

T1 = *U. decumbens* - control; T2 = no-till without desiccation; T3 = partial desiccation; T4 = total desiccation; T5 = soil scarification; T6 = plowing; T7 = plowing + harrowing. Without P = no phosphate fertilization; with P = with phosphate fertilization. CV (%) = coefficient of variation; P, K, Ca and Mg: extracted with ion exchange resin. Means followed by lower case letters in the columns and upper case in the lines differ from each other to 5% probability by the Scott-Knott test.
In relation to Ca\(^{2+}\), the P fertilization contributed to increase the Ca\(^{2+}\) concentration in the 0.0-0.1 depth, and this result was attributed to the Ca presence (18 - 20%) in the phosphate source used in this study (superphosphate simple – 20% Ca). In general, the Ca\(^{2+}\) concentration were above 7.0 mmol\(c\) kg\(^{-1}\), considered as high availability (Raij et al. 1996). While the Mg\(^{2+}\) presented values between 3.5- to 9.5 mmol\(c\) kg\(^{-1}\), considered as average availability for forage plants (Raij et al. 1996).

In relation to the initial soil chemical analysis, it is observed the soil maintenance the values of P, K\(^{+}\), Ca\(^{2+}\), and Mg\(^{2+}\). However, in relation to the values found after two years of implementation of management and fertilization systems (Rebonatti et al. 2016), there was chemical fertility recovery, since the management systems allow the cycling of nutrients that were extracted by the plants, especially those associated with no-tillage system. Although the SOM did not present a significant effect among the legume introduction systems, there was an increase in its concentration when compared with data found by Rebonatti et al. (2016) in same edaphic conditions.

The shoot dry weight (SDW) yield in each cut and the total did not present significant interaction between *Stylosanthes* and P fertilization. However, the P fertilization showed difference in presence or absence of application. The four initial cuts comprise the period without hydric stress (spring and summer), while the fifth cutting corresponds to period with hydric stress (autumn) (Table 2).

**Table 2.** Shoot dry weight (SDW) yield per cutting and SDW of *Urochloa decumbens* in different soil management system and with or without of P fertilization.

| Treatments | 1\(^{st}\) Cutting | 2\(^{nd}\) Cutting | 3\(^{rd}\) Cutting | 4\(^{th}\) Cutting | 5\(^{th}\) Cutting | Total |
|------------|---------------------|-------------------|-------------------|-------------------|-------------------|-------|
|            | kg ha\(^{-1}\)      |                   |                   |                   |                   |       |
| T\(_1\)    | 2.777A              | 2.098B            | 2.143B            | 2.827A            | 2.448B            | 12.293|
| T\(_2\)    | 2.478 A             | 1.817B            | 1.713B            | 2.151B            | 2.736A            | 10.895|
| T\(_3\)    | 2.402               | 1.908             | 2.201             | 2.477             | 2.358             | 11.346|
| T\(_4\)    | 2.299               | 2.185             | 2.205             | 2.310             | 2.710             | 11.711|
| T\(_5\)    | 2.566A              | 2.101B            | 1.907B            | 2.699A            | 2.487A            | 11.760|
| T\(_6\)    | 2.686A              | 1.834B            | 2.520A            | 2.413A            | 2.564A            | 12.017|
| T\(_7\)    | 2.061               | 1.850             | 2.313             | 2.637             | 2.368             | 11.230|
| Without P  | 2.310a              | 1.944a            | 1.980b            | 2.353b            | 2.246b            | 10.833b|
| With P     | 2.623a              | 1.997a            | 2.307a            | 2.651a            | 2.803a            | 12.381a|

\(T\(_1\) = U. decumbens\) control; \(T\(_2\) =\) no-till without desiccation; \(T\(_3\) =\) partial desiccation; \(T\(_4\) =\) total desiccation; \(T\(_5\) =\) soil scarification; \(T\(_6\) =\) plowing; \(T\(_7\) =\) plowing + harrowing. CV (%) = coefficient of variation. Means followed by lower case letters in the columns and upper case in the lines differ from each other to 5% probability by the Scott-Knott test.
Except for the control, the fifth cutting, which represents the cut during the rainy season, is among the highest yield averages. This result can be attributed to rainfall during the autumn period (Figure 1), that is usually characterized by long dry season. From the third to the fifth cut and the total yield in the period presented higher SDW with P presence. These results can be attributed by the beginning of the rainy season, in which the plants were not yet in full development caused by the stress during the dry season, as well as due to the pasture fertilization system, which is performed in and requires a longer period for soil incorporation, especially P that presents low soil mobility. The results corroborate Rebonatti et al. (2016), on study carried out in previous years, in same edaphic conditions.

The SDW in autumn and period without hydric stress (spring and summer) were similar and did not present significance in the partial desiccation (T3), total desiccation (T4) and plowing + harrow (T7). These results occurred because the year 2016 was atypical, with regular rainfall during the period that is characterized by severe drought (Figure 1). The N, P, K, Ca, Mg and S did not present a significant interaction between *Stylosanthes* spp. × P rates. However, it presented significance for the two periods of hydric deficit and for presence and absence of P fertilization (Table 3).

The N concentration presented a significant difference between the 2 season periods with 9.9 g kg\(^{-1}\) in spring and summer and 7.9 g kg\(^{-1}\) in autumn (Table 3). Despite this difference in the two periods, in all treatments presented lower levels than those considered adequate for the *U. decumbens*, ranging from 12.0- to 20.0 g kg\(^{-1}\) (Werner et al. 1996). These effects showed that the *Stylosanthes* spp. does not contribute to increase the N concentration in total *U. decumbens* composition.

In relation to P concentration, the highest concentrations were associated to P fertilization, in both periods. In the spring and summer, the concentrations ranged from 1.4 g kg\(^{-1}\) and 2.0 g kg\(^{-1}\) and in autumn 1.4 g kg\(^{-1}\) and 2.1 g kg\(^{-1}\) (Table 3). These results with those of Ieiri et al. (2010) and Moreira and Malavolta (2001), that studying sources and P rates in pasture recovery area and alfalfa (*Medicago sativa* L.), respectively, obtained a significant response regarding the presence of P fertilization. Even with the difference in SDW, no difference was observed in relation to the periods evaluated (Table 3). Although the P values are in the range considered adequate for *U. decumbens* ranging from 0.8- to 3.0 g kg\(^{-1}\) (Werner et al. 1996), it is important to emphasize the contribution of phosphate fertilization on forage quality in relation to the P presence in the animal diet.
Table 3. Macronutrient concentrations in shoot dry of the *Urochloa decumbens* in different soil management conditions and with or without of P fertilization: a) without hydric deficit, WTDH [spring and summer (third cutting)] and b) with hydric deficit, WDH [autumn (fifth cutting)].

| Treatments  | N  | P  | K  | Ca  | Mg  | S   |
|-------------|----|----|----|-----|-----|-----|
| WTDH WDH    |    |    |    |     |     |     |
| T1          | 9.5| 9.0| 1.6| 1.8 | 18.0A| 13.8B|
| T2          | 9.6| 8.4| 1.7| 1.8 | 17.5A| 13.0B|
| T3          | 9.0| 8.7| 1.6| 1.8 | 17.5  | 15.0 |
| T4          | 9.9A| 7.9B| 1.8 | 1.8 | 18.1A| 13.4B|
| T5          | 8.7| 8.6| 1.8 | 1.7 | 16.4  | 13.2 |
| T6          | 9.7| 8.2| 1.8 | 1.7 | 18.0A| 13.0B|
| T7          | 9.8| 8.5| 1.7 | 1.7 | 17.9  | 13.1 |
| Without P   |    |    |    |     |     |     |
| With P      |    |    |    |     |     |     |
| CV (%)      | 19.1| 16.6| 32.1| 18.8| 28.2| 16.9|

T1 = *U. decumbens* - control; T2 = no-till without desiccation; T3 = partial desiccation; T4 = total desiccation; T5 = soil scarification; T6 = plowing; T7 = plowing + harrowing. CV (%) = coefficient of variation. Means followed by lower case letters in the columns and upper case in the lines differ from each other to a 5% probability by the Scott-Knott test.

In the period without hydric stress, the K concentration was higher in relation to the period with hydric stress, except in the partial desiccation, soil scarification and plowing + harrowing systems. This result can be associated to nutrient dynamics in the soil, which in the presence of moisture occurs greater availability and diffusion in the soil, increasing its uptake (Havlin et al. 2005). However, due to hydric restriction, the total ions concentration in solution increases, but the Ca\(^{2+}\) and Mg\(^{2+}\) concentrations increase faster than K, because the cation ratio activity in solution is constant (Gapon Equation), which explains the lower K uptake in autumn and higher Ca uptake (Table 3). Therefore, it is necessary to provide all nutrients in a balanced manner to reduce the conditions limiting the growth and plants development (Fernandes 2006). In general, the K concentrations are within the range considered adequate for grazing (Werner et al. 1996). Despite the presence of sulphate (12%...
S) in simple superphosphate, the Mg and S concentrations, the values are within the range considered adequate and can be considered random within the experimental study. The reference values for plant nutrition suitable for Mg and S are, respectively, 1.5- to 4.0 g kg$^{-1}$ e 0.8- to 2.5 g kg$^{-1}$ (Werner et al. 1996).

4. Conclusion

After four years of experiments, the soil management strategies for the introduction of *Stylosanthes* spp. in *U. decumbens* grazing did not affect the soil chemical properties and the SDW yield was not significant. The P fertilization in the soil increase in relation to the find values in the implantation of the experiment, especially in the treatments with nutrient application, and the soil fertility construction took place. Phosphorus fertilization provide higher P concentration in forage and increase SDW yield. No significant differences were observed in the N, K, Ca, and Mg concentration in SDW of *U. decumbens* with introduction of *Stylosanthes* spp. and P fertilization. At 0.00-0.10 and 0.10-0.20 m depths, regardless of the management system, the P application of altered the K, Ca and Mg contents of the soil.

References

CIIAGRO. Centro integrado de informações agrometerológicas. (2016). Review Maps of Andradina, São Paulo State, Brazil [Mapas da Resenha de Andradina, Estado de São Paulo, Brasil]; [accessed 2018 jul 15]. http://ciiagro.sp.gov.br/ciiagroonline/menuresenha.htm.

Costa, K. A. P., Faquin, V. & Oliveira, I. P. (2009). Doses and sources of nitrogen on mineral nutrition in marandu grass. *Ciência Animal Brasileira* 10(1):115–123.

Cubilla, M. M., Amado, T. J. C., Wendling, A., Eltz, F. L. F. & Mielniczuk, J. (2007). Calibration of phosphorus fertilization rates for main grain crops under no-till in Paraguay. *Revista Brasileira de Ciência do Solo* 16(6):1463–1474.

Fageria, N. K., Baligar, V. C., Moreira, A. & Moraes, L. A. C. (2013b). Soil phosphorous influence on growth and nutrition of tropical legume cover crops in acidic soil. *Communications in Soil Science and Plant Analisys* 44(22):3340–3364.
Fageria, N. K., Moreira, A. & Santos, A. B. (2013a). Phosphorus uptake and use efficiency in field crops. *Journal of Plant Nutrition* 36(13):2013–2022.

Fernandes, M. S. (2006). *Mineral Nutrition of Plants* (Nutrição Mineral de Plantas). Viçosa (Brazil): Sociedade Brasileira de Ciência do Solo.

Ferreira, P. A. A., Girotto, E., Trentin, G., Miotto, A., Melo, G. W., Ceretta, C. A., Kaminski, J., Frari, B. K. D., Marchezan, C., Silva, L. O. S., Faversani, J. C. & Brunetto, G. (2014). Biomass decomposition and nutrient release from black oat and hairy vetch residues deposited in a vineyard. *Revista Brasileira de Ciência do Solo* 38:1621–1632.

Havlin, J. L., Beaton, J. D., Tisdale, S. L. & Nelson, W. L. (2005). *Soil Fertility and Fertilizers*. Upper Saddle River: Pearson Education.

Heinrichs, R. & Soares Filho, C. V. (2014). *Fertilization and management of pasture: II Symposium of fertilization and pasture management* [Adubação e manejo de pastagens: II Simpósio de adubação e manejo de pastagens]. Birigui (Brazil): Boreal.

Ieiri, A. Y., Lana, R. M. Q., Korndörfer, G. H. & Pereira, H. S. (2010). Sources, doses, and application method of phosphorus in the recovery of *Brachiaria* pasture. *Ciência e Agrotecnologia* 34(5):1154–1160.

Malavolta, E., Vitti, G. C. & Oliveira, S. A. (1997). *Evaluation of Nutritional Status of Plants; principles and perspectives* [Avaliação do estado nutricional das plantas: princípios e aplicações]. Piracicaba, Brazil: Potafos.

Melo, M. P. (2016). Efeito de fontes e doses de fósforo em gramíneas forrageiras. Tese (Doutorado Produção vegetal). Universidade Federal Tocantins, Gurupi, 112.

Moreira, A. & Malavolta, E. (2001). Sources, rates and extractants of phosphorus on alfalfa and centrosema. *Pesquisa Agropecuária Brasileira* 36:1519-1527.
Moreira, A., Malavolta, E. & Moraes, L. A. C. (2002). Efficiency of phosphorus sources and rates for alfalfa and centrosema cultivated in an Yellow Latosol (Oxisol). *Pesquisa Agropecuária Brasileira* 37(1):1459–1466.

Pietramale, R.T.R., Josimari Regina Paschoaloto, J.R., Valentim, J.K., Marques, O.F.C., Leite, B.K.V., Petromali, G.F.S.G., Castilho, V.A.R., Barbosa, D.K., Ruviaro, C.F., Oliveira Neto, S.S. & Heinrichs, R (2020). Marandu grass production under nutrient deficient conditions at different cutting times. *Research, Society and Development*, 9(4): e170943058.

Raij, B. van, Andrade, J. C., Cantarella, H. & Quaggio, J. A. (2001). *Chemical Analysis to Evaluate the Fertility of Tropical Soils* [Análise Química para Avaliação da Fertilidade de Solos Tropicais]. Campinas, Brazil: Instituto Agronômico.

Raij, B. van, Cantarella, H., Quaggio, J. A. & Furlani, A. M. C. (1996). *Fertilization and Liming Recommendations for the São Paulo State* [Recomendações de Adubação e Calagem para o Estado de São Paulo]. Campinas (Brazil): Instituto Agronômico de Campinas.

Rebonatti, M. D., Fabrice, C. E., Santos, J. M. F., Heinrichs, R., Soares Filho, C. V. & Moreira, A. (2016). Chemical attributes of soil and forage yield of pasture recovered with phosphate fertilization and soil management. *Communications in Soil Science and Plant Analysis* 47(18):2069–2076.

Sansonowicz, C., Lobato, E., & Goedert, W. J. (1987). Residual effects of lime and phosphorus sources in pastures on Cerrado soil. *Pesquisa Agropecuária Brasileira* 22(3):233–243.

Santos, H. G. (2018). *Brazilian System of Soil Classification* [Sistema brasileiro de classificação do solo]. Brasília (Brazil): Embrapa Solos.

Santos, J. Z. L., Furtini Neto, A. E., Resende, A. V., Curi, N., Carneiro, L. F. & Costa, S. E. V. G. A. (2008). Phosphorus fractions in soil cultivated with corn as affected by different phosphates and application methods. *Revista Brasileira de Ciência do Solo* 32:705–714.
Schaefer, C. E. R., Silva, D. D. Paiva, K. W. N., Pruski, F. F., Albuquerque Filho, M. R. & Albuquerque, M. A. (2002). Soil, nutrient and organic matter losses in a Red-Yellow Podzolic under simulated rainfall. *Pesquisa Agropecuária Brasileira* 37(5):669–678.

Shapiro, S. S. & Wilk, M. B. (1965). An analysis of variance test for normality. *Biometrika* 52(1):591–611.

Silva, D. J., & Queiroz, A. C. (2002). *Food Analysis; chemical and biological methods* [Análises de Alimentos (métodos químicos e biológicos)]. Viçosa (Brazil): Universidade Federal de Viçosa.

Silva, J. J., & Saliba, E. O. S. (2007). Consortium pastures: an alternative for extensive and organic systems. *Veterinária e Zootecnia* 14(1):8–18.

Tan, Z., Owens, R., Lal, L. & Izaurralde, R. C. (2007). Distribution of light and heavy fractions of soil organic carbon as related to land use and tillage practice. *Soil Tillage Research* 92(1):53-59.

Werner, C., Ryel, R. J., Correia, O. & Beyschlag, W. (2001). Structural and functional variability within the canopy and its relevance for carbon gain and stress avoidance. *Acta Oecology* 22(1):129–138.

Werner, J. C., Paulino, V. T., Cantarella, H., Andrade, N. O. & Quaggio, J. A. (1996). Forages [Forrageiras]. In *Fertilization and Liming Recommendations for the São Paulo State* [Recomendações de Adubação e Calagem para o Estado de São Paulo], ed. Raí B. van, H. Cantarella, J. A. Quaggio, & A. M. C. Furlani. p. 261–273. Campinas (Brazil): Instituto Agronômico de Campinas.
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