NPK Management for Forage Grasses in Brazil

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Most pasture land in Brazil is inherently low in nutrients and improved soil fertility and acidity management has the potential to raise both animal performance and the efficiency of beef production.
This article reviews forage fertility management – highlighting its impact on yield, quality, and system profitability.

Brazil's pastures currently support the world's largest commercial bovine herd, which makes the country the second largest beef producer and exporter. About 90% of livestock production in Brazil is grassland-based, but these areas are very diverse regarding technology adoption and this can have a large influence on the types of forage grown and the breeds of cattle raised. Considering Brazil's 180 million (M) ha of land in pasture and its 212 M head of cattle, the country's average stocking rate is about 1 head per hectare. In terms of land use this system can be characterized as inefficient, but it has the potential to be improved with soil amelioration to correct soil acidity and increase nutrient availability, and through the adoption of better grazing techniques.

E. Francisco/IPNI

Well-managed pasture lands in Mato Grosso, Brazil.

Most of Brazil's soils are highly weathered tropical soils with low nutrient (especially P) availability, medium to high acidity (H^+ and Al^{3+}), low base saturation, and low organic matter content. The country is the fourth largest fertilizer consumer with about 34 M t of products used in 2016. However, only 1.5% of that amount is applied to pasture land, while soybeans, maize, sugarcane, coffee, and cotton consume over 80% of the total (ANDA, 2016).

Estimates are that about 50% of the pastures in the Cerrado region are considered to be degraded to some degree. Pasture degradation is mainly related to excessive grazing and crop nutrient deficiencies due to adverse soil conditions (low fertility, acidity, and compaction), leading to low biomass production and poor plant vigor. Extensive areas devoted to pastures, cultural habit of low input systems, poor access to public or private funding, misinformation, and lack of sound agronomic assistance are the main reasons for low technology adoption, including fertilizer use, by farmers. Nevertheless, some cases of success in fertilizing pastures are showing high potential for beef production, thus IPNI has promoted webinars, presentations, and demonstrations to educate farmers on the benefits of adequate use of nutrients in livestock systems and how profitable it can be.

Recommendations

Fertilizer recommendations for forage grasses in the country are based on soil analysis, species nutrient requirements, and level of technology employed. **Table 1** presents a classification of grasses according to their nutrient demand.

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulfur; Ca = calcium; Mg = magnesium; Al = aluminum; H = hydrogen; ppm = parts per million.

Liming

Multiple species of *Bracharia* grass represent the majority of forages used in Brazilian pastures. Some of these grasses are tolerant of soil acidity and have relatively low nutrient requirements. Nevertheless, *Brachiaria* grasses do respond positively to liming and fertilizer application, as has been demonstrated in several studies. Liming reduces Al^{3+} toxicity, provides Ca^{2+} and Mg^{2+}, and increases nutrient use efficiency for subsequent fertilizer applications. According to Vilela et al. (2004), liming recommendations for pastures in the Cerrado region, based on soil base saturation (BS), vary according to species tolerance to soil acidity or low soil fertility: 60% BS for less tolerant grasses (group 1; **Table 1**), 50% BS for moderately tolerant grasses

Table 1. Classification of grasses according to nutrient requirement.

Group	Level of nutrient requirement	Species (cultivars)
1	High	*Panicum maximum* (Aruana, Colonião, Tanzânia, Mombaça); *Cynodon* (Coast-cross, Tifton); *Pennisetum purpureum* (Cameron, Elefante, Napier); *Digitaria decumbens* (Pangola, Transvala); *Chloris* (Rhodes)
2	Medium	*Brachiaria brizantha* (Marandu, Xaraés, Piatã); *Andropogon gayanus* (Andropogon); *Cynodon plectostachyus* (Estrelas); *Paspalum guenoarum* (Ramirez)
3	Low	*Brachiaria decumbens* (Braquiária, Ipean, Australiana); *B. humidicula* (Quicuio da Amazônia); *Paspalum notatum* (Batatais, Pensacola); *Setaria anceps* (Setária)

Source: Werner et al. (1997).

Table 2. Phosphorus and potassium recommendations for the establishment and maintenance of pastures in the Cerrado, based on soil analysis and nutrient demand of plants or level of technology adoption.

Level of nutrient demand or technology adoption	Soil P[1]				Soil K		
	Very low	Low	Medium	Optimum	Low	Medium	Optimum
	P_2O_5, kg/ha[2]				K_2O, kg/ha		
	Establishment[3]						
Low (<1 AU[5]/ha)	40-120	30-90	20-60	0	20	0	0
Medium (1-3 AU/ha)	70-180	55-135	35-90	0	40	20	0
High (3-7 AU/ha)	80-240	50-150	40-120	0	60	30	0
	Maintenance[4]						
Low (<1 AU/ha)	-	15-40	0	0	40	0	0
Medium (1-3 AU/ha)	-	20-50	15-30	0	100	40	0
High (3-7 AU/ha)	-	30-60	15-40	0	200	100	0

[1] Interpretation of Mehlich 1 P availability depends on soil clay content.
[2] Rates of P_2O_5 varies according to soil clay content in direct relation.
[3] Soluble sources of P are recommended in furrow or broadcast plus incorporation. Potassium application can be broadcasted.
[4] Single broadcast application in the beginning of rainy season for P and K (<40 kg K_2O/ha). Split broadcast applications with 30-day intervals for K_2O rates >40 kg K_2O/ha.
[5] Animal unit: 454 kg cow.
Source: Vilela et al. (2004) and Cantarutti et al. (1999).

(group 2), and 35% BS for highly tolerant grasses (group 3). The authors also recommend that when the concentration of Mg^{2+} is below 0.5 $cmol_c$/kg, a dolomitic type of lime should be applied.

Another practice that may be adopted to mitigate subsoil acidity is phosphogypsum (PG) application. It reduces the degree of Al^{3+} saturation in the subsoil and provides Ca^{2+} and SO_4-S to plants. The use of PG in Brazil is common for several crops with no unacceptable risk to soil or plants (Dias et al., 2010). The criteria for PG recommendation takes into consideration the condition of the subsoil (0.2 to 0.4 m depth). Specifically, where Al^{3+} saturation is higher than 20% or Ca^{2+} is below 0.5 $cmol_c$/kg, the recommended application rate is 50 kg of PG per % of clay in the soil (Vilela et al., 2004).

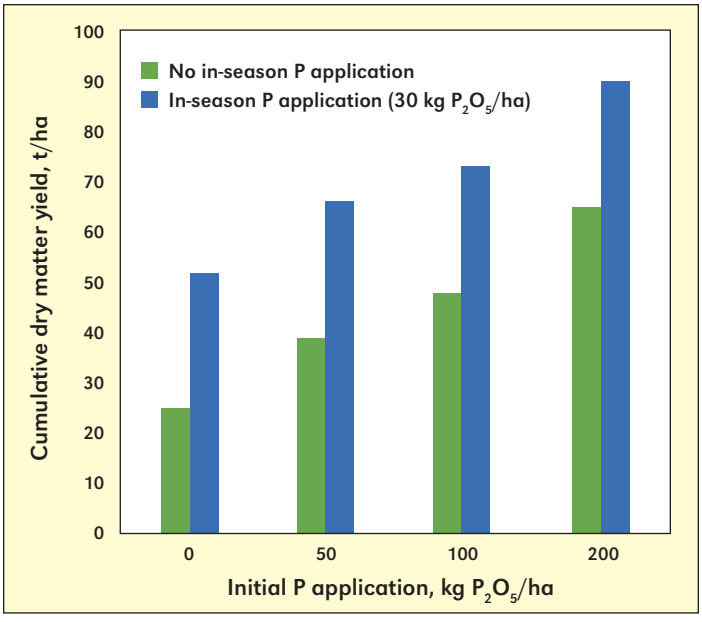

Figure 1. Cumulative dry matter yield (7 years, 16 cuttings) of *Brachiaria decumbens* in response to P application rates and levels of maintenance (no additional application versus biannual application of 30 kg P_2O_5/ha). Original soil conditions: pH (water) 4.6, P (Mehlich 1) 0.8 ppm, and Base Saturation 8%. Source: Soares et al. (2001).

Phosphorus and Potassium

Recommendations for P and K fertilizer rates in Brazil's pastures are based on the nutrient requirement of grass plus a soil analysis (**Table 2**). For grasses with low nutrient demand (group 3), fertilizer rates may vary to supply 20 to 120 kg P_2O_5/ha and up to 20 kg K_2O/ha depending on soil availability. For grasses with high nutrient demand (group 1), application rates vary from 40 to 240 kg P_2O_5/ha and up to 60 kg K_2O/ha. However, depending on the grass and level of intensification, K rates may need to be higher to support plant growth and quick recovery—up to 200 kg K_2O/ha yearly.

In Cerrado soils, P fixation is high. Therefore, liming is a best management practice (BMP) to increase soil P availability and promote its efficient use by plants. As pastures are perennial crops, P application in the seed furrow or broadcasted followed by incorporation is recommended prior to pasture establishment. For maintenance, a single broadcast application of P fertilizers (20 to 40 kg P_2O_5/ha) at the beginning of rainy season is recommended, as presented in **Figure 1**.

Soluble sources of P are recommended for their prompt availability, but phosphate rock (PR) or partial acidulated fertilizers may be an option in some regions. If PR is to be used, it is recommended that application occurs at the establishment of pastures and be incorporated into the soil. Phosphorus application is required to achieve high biomass yields in intensified livestock systems, as is shown in **Table 3**. Recommended P rates should be applied at the establishment of pastures to promote early vigorous plant growth and development of an adequate root system which leads to sustainable biomass production along with lowered risk of soil degradation.

Table 3. Dry matter yield (t/ha) of *Brachiaria decumbens* in response to N and P application rates.

P_2O_5 rate, kg/ha	N rate, kg/ha			
	0	75	150	300
0	3.35	-	-	-
60	3.39	8.14	9.95	11.8
120	3.56	8.31	12.1	15.3

Original soil conditions: pH ($CaCl_2$) 5.4, P (Resin) 5 ppm, and Base Saturation 55%. Source: Lupatini et al. (2010).

Potassium fertilizers may be broadcast on the soil surface at pasture establishment and at the beginning of rainy season (< 40 kg K_2O/ha). For maintenance of more intensive production systems demanding higher K rates, split broadcast applications in 30-day intervals are recommended. Tropical grasses require large amounts of K, which is an important nutrient to control evapotranspiration and sustain high photosynthesis performance of C4 plants. In soils low in K, plants struggle to accumulate biomass and the response to N application is compromised (**Figure 2**).

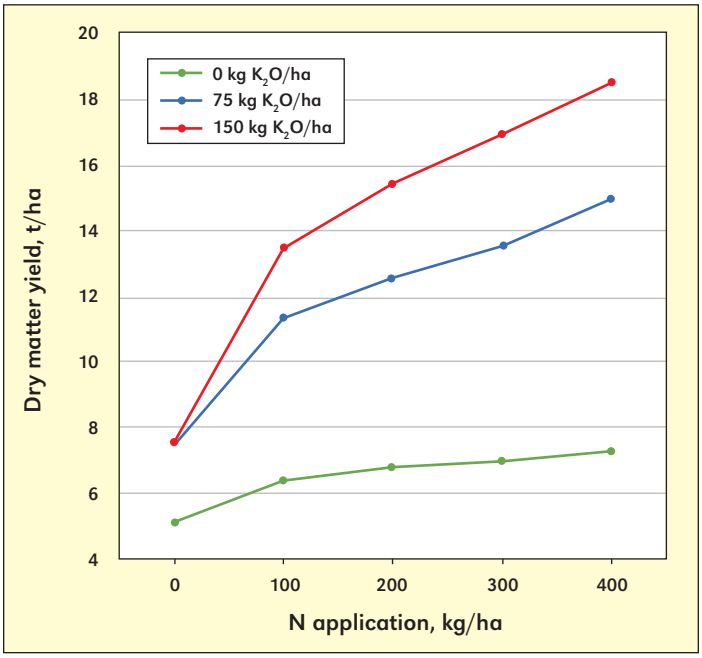

Figure 2. Cumulative dry matter yield of *Brachiaria decumbens* in response to N and K application rates. Original soil condition: pH (water) 4.6, OM 3%, and K (Mehlich 1) 42 ppm. Carvalho et al. (1991).

Nitrogen

Nitrogen is a key nutrient to promote biomass production, and C4 plants in tropical environments are very responsive to N. The recommended rate for N fertilizer will vary widely depending on soil conditions, plant demand, technology adoption by the farm, and irrigation. Vilela et al. (2004) recommend 50 kg N/ha, along with 30 kg S/ha for the establishment of pastures in the Midwest. Cantarutti et al. (1999) recommend the same amount of N and S for livestock systems using moderate technology, but 100 to 150 kg N/ha for farms using more advanced technology. For the maintenance of pastures, Vilela et al. (2004) recommend 100 to 150 kg N/ha for medium-tech farms and 200 kg N/ha in higher-tech farms. It is recommended that the higher N rates be split into three applications of at least 50 kg N/ha during the beginning, middle, and end of the rainy season. The authors encourage the use of ammonium nitrate or ammonium sulfate to avoid potential N losses due to volatilization. Urea may be used if soil and weather conditions are monitored to ensure adequate soil moisture, mild temperatures, and an application just prior to a rain if possible. For highly intensive livestock systems, N rates may also be adjusted according to other parameters (e.g., grazing efficiency, level of farm management) as is indicated in **Table 4**. Recent research studies show positive results for balanced applications of 1:1 for N:K, and 10:1 for N:S.

Table 4. Nitrogen requirement considering the impact of farming management on N use efficiency (NUE) and grazing harvest efficiency (GHE).

Farming management	NUE, kg DM[1]/kg N	GHE[2], %	N requirement, kg N/AU[3]
Very low	<30	<40	170
Low	30-35	40-45	130
Medium	35-40	45-50	100
High	40-45	50-55	85
Very high	45-50	55-60	70
Excellent	>50	>60	60

[1] Dry matter yield.
[2] GHE is the percent of vegetation ingested through grazing compared to the total amount of vegetation.
[3] Animal unit: 454 kg cow.
Source: Martha Junior et al. (2004).

Table 5. Dry matter accumulation rate of *Brachiaria brizantha cv. Marandu*, stocking rate, and beef yield in response to N application rates.

N rate, kg/ha	DM accumulation rate, kg/ha/day	Stocking rate, AU[1]/ha	Beef production, kg/ha
50	29.1 b[2]	2.55 b	697 b
200	51.9 a	3.44 a	863 a

[1] Animal unit: 454 kg cow.
[2] Values in each column followed by different letter are statistically different at $p = 0.05$.
Source: Gimenes et al. (2011).

Complete and balanced plant nutrition and efficient grazing management are key to obtaining high yields of biomass and beef in livestock systems as shown in **Table 5**. Improving soil fertility via appropriate nutrient management is the first step for recovering degraded pastures, and increasing dry matter yield and forage quality. Certainly, the use of nutrients associated with BMPs is a profitable path for livestock farmers. BC

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