Increasing Beef Production with Improved Soil Nutrient Use: Brazil's Challenge

By Eros Francisco

Pasture for grazing is the major land use in Brazil, but the country's livestock systems are generally very inefficient.

Brazil has great potential to increase its beef production, but farmers will need to follow results from agronomic research and adopt recommended technologies.

Liming, fertilizer use, and other techniques are useful best management practices to change this current reality.

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Livestock farming systems examples in Brazil with low (left) and high (right) technology adoption.

Brazil's livestock-related agriculture currently occupies 25% of the country's total area of 851 million (M) ha. Agriculture for livestock is the largest land use type compared to other uses including: federal lands (18%), conservation units (15%), forests and natural vegetation (13%), Indian reservations (13%), other purposes (15%), and cities and infrastructure (0.2%). About one quarter of the area occupied by livestock agriculture is used to grow crops; however, the remaining land (about 180 M ha) grows forage grasses mainly for grazing (IBGE, 2015).

Forage production systems in Brazil are very diverse with 45% growing native vegetation and 55% cultivated forages. Half of Brazil's pastures are considered to be degraded to some degree. The main causes of pasture degradation are related to adverse soil conditions (low fertility, acidity, and compaction), selecting the wrong plant species (variety adaptation or low tolerance to soil/climate conditions), and inadequate pasture management (weed competition, low seed germination, wrong seeding rate, etc.). Despite this, these pastures support the world's largest (212 M head) commercial cattle herd (IBGE, 2015), which makes Brazil the second largest beef producer and exporter in the world.

Most of Brazil's tropical soils are weathered with low nutrient availability (especially P), medium to high acidity (H^+ and Al^{3+}), and low organic matter content. Therefore, and because of the amount of land devoted to grain production, the country is the world's fourth largest fertilizer consumer with about 32 M t of fertilizer products used in 2015. But according to the National Fertilizer Association (ANDA, 2015), only 1.5% of that amount is designated to pasture land, while soybeans, maize, sugarcane, coffee, and cotton consume 91% of the total.

Brazil's average stocking rate is about 1 head per ha. In terms of actual land use, this is a very inefficient livestock system that can be improved by BMPs including soil amelioration (correcting acidity and increasing nutrient availability) and better grazing methods.

Why don't livestock farmers apply fertilizer to their fields? Cunha (2013) lists the following four reasons: 1) tropical grasses have a low nutrient requirement, 2) famers rarely associate low biomass production with low soil fertility and don't usually perceive a return from fertilizer, 3) livestock systems have poor grazing efficiency, and 4) technical assistance is scarce.

Recommendations

Multiple species of *Brachiaria* grass dominate the great majority of forages used in Brazilian pastures. Some of these grasses are commonly known to be tolerant to soil acidity and to have a relatively low nutrient requirement. Despite such characteristics, *Brachiaria* grasses do respond positively to liming and fertilizer application, as demonstrated by several studies.

Figure 1 shows dry matter yield of *Brachiaria decumbens*

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; S = sulfur; Ca = calcium; Mg = magnesium; Al = aluminum; H^+ = hydrogen ion; BMP = best management practice; US$1 = R$3.2 (Brazilian Real).

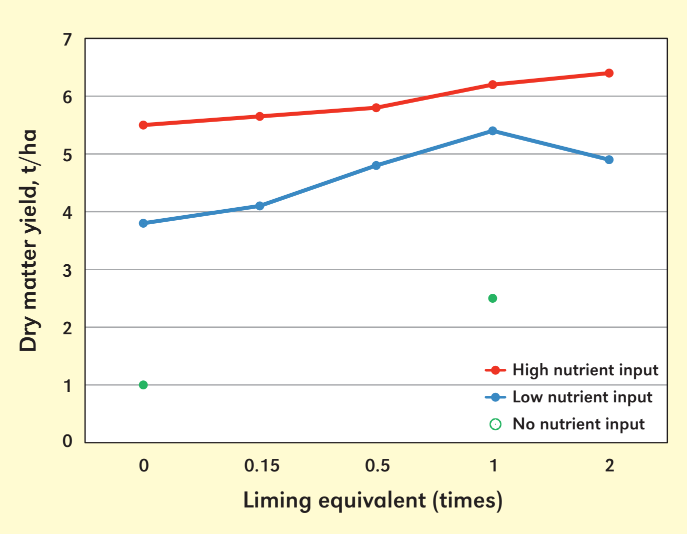

Figure 1. Dry matter yield of *Brachiaria decumbens* in response to liming and nutrient application. Adapted by Barcelos et al. (2011).

Table 1. Dry matter yield of *Brachiaria brizantha* cv. Marandu in response to phosphogypsum application.

	Dry matter yield, t/ha	
Phosphogypsum rate, kg/ha	Year 1	Year 2
0	3.4	5.8
200	4.2	8.7
1,500	4.5	9.7

Source: Souza et al. (2011).

Table 3. Dry matter yield of *Brachiaria decumbens* in response to N and P rates.

	- - - - - - - - - - - - N rate, kg/ha - - - - - - - - - - - -			
P_2O_5 rate, kg/ha	0	75	150	300
0	3.4	-	-	-
60	3.4	8.1	10	12
120	3.6	8.3	12	15

Source: Lupatini et al. (2010).

in response to liming and levels of nutrient application. 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: 35% BS for highly tolerant grasses (i.e., *Brachiaria decumbens*, *Brachiaria humidicola*, and *Andropogon* gayanus), 45% BS for moderately tolerant grasses (i.e., *Brachiaria brizantha cv.* Marandu, *Panicum maximum cv.* Vencedor, and *Setaria anceps*), and 55% BS for less tolerant grasses (i.e., *Panicum maximum cv.* Tanzânia, *Panicum maximum cv.* Mombaça, *Pennisetum purpureum*, *Cynodon* spp). The authors also recommend that when the level of Mg is below 0.5 $cmol_c$/kg, a dolomitic type of lime should be used.

Another practice that may be adopted to mitigate subsoil acidity is phosphogypsum application. Phosphogypsum is commonly recommended at 50 kg/ha for each percent clay in the soil. Phosphogypsum will reduce the level of Al^{3+} saturation in the subsoil and provide plant with S in the form of sulfate (SO_4^{2-}). **Table 1** presents two years of results with *Brachiaria brizantha cv.* Marandu in response to phosphogypsum application.

Recommendations for P and K fertilizer rates in Brazil's pastures are based on the nutrient requirement of the grass plus a soil analysis (**Table 2**). In soils low in P, the response to P application may exceed the effect of other nutrients. In some Cerrado soils, P fixation is extreme and creates strong competition between the soil and plant. As a result, liming is a BMP to increase soil P availability and promote its efficient use by plants. As pastures are perennial crops, P application and incorporation is recommended prior to seeding. Phosphorus application is necessary to achieve high dry matter yields in intensified livestock systems (**Table 3**).

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 P-Mehlich 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).

Tropical grasses take up high amounts of K, which is

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Examples of integration of livestock, cropping, and forestry to achieve better use of pasture lands. (Top to Bottom: *Brachiaria* grass planted with maize, forage grass planted after soybean, forage grass planted with trees).

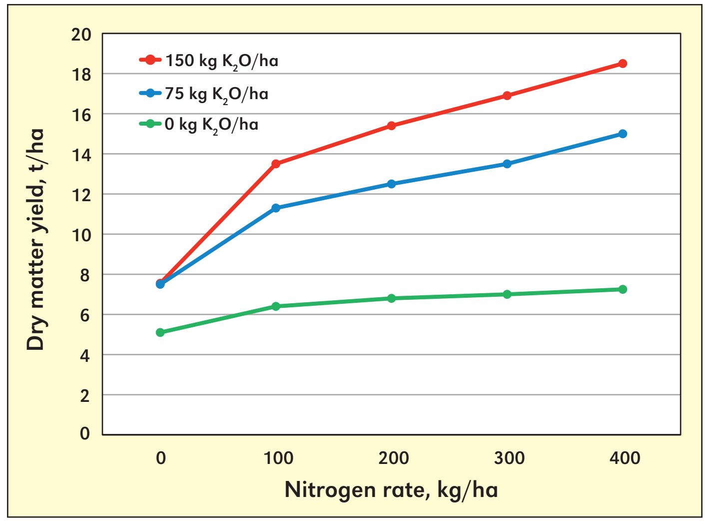

Figure 2. Cumulative dry matter yield of *Brachiaria decumbes* in response to N and K rates. Source: Carvalho et al. (1991).

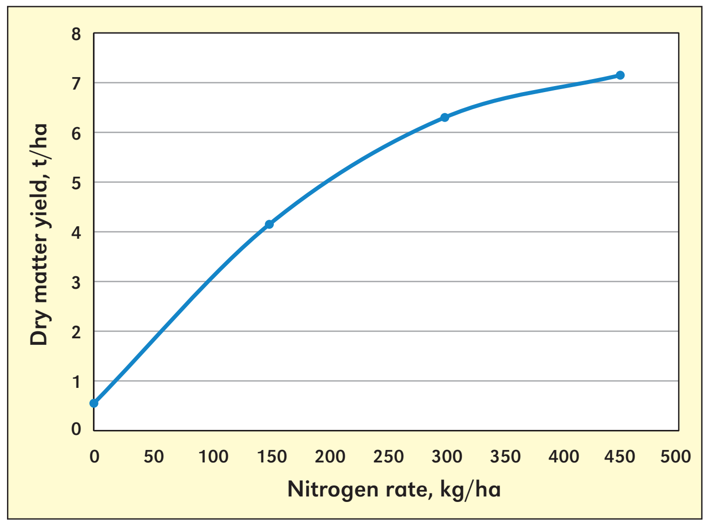

Figure 3. Dry matter yield of *Panicum maximum* in response to N rates. Source: Sarmento (2005).

an important nutrient to control evapotranspiration and sustain the high photosynthetic performance of C4 plant types. In soils low in K, plants struggle to accumulate biomass and the response to any N application is compromised (**Figure 2**).

Nitrogen is a key nutrient to promote biomass production and C4 plants grown in tropical environments are very responsive to N (**Figure 3**).

Rates recommended for N fertilizer will vary widely depending on soil conditions, plant demand, technology adoption by the farm, and irrigation. Vilela et al. (2004) recommended 50 kg N/ha, along with 30 kg S/ha for the establishment of pastures in the Cerrado. Cantarutti et al. (1999) recommended the same amount of N and S for livestock systems using moderate technology, but 100 to 150 kg N/ha in farms using higher technology. For the maintenance of pastures in the Cerrado, Vilela et al. (2004) recommended 100 to 150 kg N/ha for medium-tech farms and 200 kg N/ha in higher-tech farms. These higher N rates are recommended to 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

Table 4. Nitrogen requirement considering the impact of faming management on N use efficiency (NUE) and grazing efficiency (GE).			
Farming management	NUE, kg DM[1]/kg N	GE, %	N requirement, kg N/AU[2]
Very bad	<30	<40	170
Bad	30-35	40-45	130
Medium	35-40	45-50	100
Good	40-45	50-55	85
Very good	45-50	55-60	70
Excellent	>50	>60	60

[1]Dry matter yield.
[2]Animal unit: 454 kg cow.
Source: Martha Junior et al. (2004).

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 when possible. For highly intensive livestock systems, N rates may also be adjusted according to other parameters (i.e., grazing efficiency, level of farm management) as is suggested in **Table 4**.

Benefits

Despite the low efficiency of most of the livestock farming systems in Brazil due to very low stocking rates, some farmers are showing impressive beef yields with the adoption of new techniques and technology (e.g., correctly managing grazing harvest, investing in improved animal genetics, and applying fertilizers to increase soil fertility to sustain high biomass production). **Table 5** shows a successful farm in the state of Mato Grosso do Sul that achieved high beef productivity by significantly increasing stocking rates compared to the state's average, and other low-tech farms.

Regions of Brazil are also successfully integrating their livestock production with annual crop or tree production systems. For example, *Brachiaria* can be established along with maize (second crop) in the Cerrado. The strategy results in a well-established forage grass soon after maize harvest. Similarly, grasses are grown as a second crop after soybean and are grazed for five months before the next cropping season; or are grown along with tree species where annual crops are no longer in the system.

Summary

There are many ways to improve the efficiency of livestock farming systems, including the use of fertilizers to correct soil nutrient deficiencies. Brazil's beef productivity will have to increase with time, which means pasture lands must be managed better. Livestock producers face the economic choice to either decide to stay in business, or concede to the increasing pressure to convert more land into grain production. Certainly, the use of nutrients associated with best management practices is a profitable path for livestock producers. BC

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Table 5. Comparison of livestock farming systems in the state of Mato Grosso do Sul, Brazil.

System[1]	DM yield, t/ha/yr	Stocking rate, kg/ha	Stocking rate, heads/ha	ADG[2], kg/day	Beef yield, kg/ha/year	Total cost, R$/kg	Operating profit, R$/ha/year
State	unknown	400	1.30	0.35	82.9	3.38	216
Low-tech	4.3	380	1.24	0.46	118.0	3.50	295
High-tech	38.1	3,720	10.7	0.62	1,287	3.22	3,559

[1]Systems: State average, low input of technology, high input of technology (liming, fertilizer application, and irrigation).
[2]Average daily gain of weight.
Source: Adapted from Aguiar (2015).