A Look at the Nutrient Budget for Brazilian Agriculture

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A nutrient budget is an important tool used to evaluate fertilizer use through its presentation of the balance between inputs and outputs in crop production. IPNI has prepared several nutrient budgets for Brazil over the years: Yamada and Lopes (1998), Cunha et al. (2010; 2011; 2014). This article focuses on this most recent study, which examined crop production between 2009 and 2012. Historical trends for fertilizer use (and crop productivity) are also put into perspective.

The authors began with manufactured mineral fertilizer (input) data obtained from annual statistics (ANDA, 2010 to 2013). Crop nutrient removals (output) were calculated using data for 18 crops including: banana, beans, cassava, castor bean, cocoa, coffee, cotton, maize, orange, peanut, potato, rice, sorghum, soybean, sugarcane, tobacco, tomato, and wheat (IBGE, 2010 to 2013) and their respective nutrient concentration in harvested product (Cunha et al., 2014). The 18 crops represent 93% of all nutrient input in Brazil.

Regional Budgets

Average annual nutrient use in Brazil between 2009 and 2012 was 2.84, 3.47 and 3.79 million (M) t of N, P_2O_5 and K_2O, respectively (**Table 1**). The midwest region showed the highest NPK use with 31% of total, followed by the south and southeast, each with 28% of the total. The northeast and north only had 11% and 2% of the total nutrient use, respectively.

The midwest was responsible for 36% and 34% (1.24 and 1.29 M t) of the total P_2O_5 and K_2O use, respectively. This region provides the core of soybean and maize production in Brazil, and plant-available soil P and K in the midwest is inherently low. The southeast accounted for 38% (1.08 M t) of the total N use due to the large areas of sugarcane, orange and coffee production. The amount of N fixed by soybean and common beans was assumed to be 100% and 50% of removal, respectively, and was considered an input.

Crop removal represented an average of 90%, 53% and 80% of N, P_2O_5 and K_2O inputs (**Table 1**). The only region where N and K_2O crop removal exceeded inputs was in the north (+11% for N and +4% for K_2O), which is attributed to low technology adoption and low yields in the region.

For P, the relatively low removal-to-use value of 0.53 reflects the typical dynamics for P in tropical soils, which promote P fixation. But in Brazil, low P removal-to-use is also influenced by recent increases in crop production in newly farmed areas where soil P levels are very low and P application is necessarily high to meet crop demand.

For N, its 0.90 removal-to-use ratio demonstrates the great contribution of biological N fixation in soybeans, which is the most cultivated crop in the country—approximately 28 M ha in 2012.

Potassium, the most commonly applied crop nutrient in

Abbreviations and Notes: N = nitrogen; P = phosphorus; K = potassium. IPNI Project # IPNI-2014-BRA-63

Geographic regions of Brazil.

Table 1. Annual nutrient budgets for regions in Brazil (average of 2009-2012).

	Crop removal			Legume fixation[1]	Nutrient applied[2]			Balance			Removal-to-use ratios		
	N	P_2O_5	K_2O	N	N	P_2O5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Region	----	----	----	----	million t	----	----	----	----	----			
South	2.21	0.64	0.91	1.53	0.85	1.03	0.96	0.18	0.39	0.05	0.93	0.62	0.95
Midwest	2.57	0.69	1.06	2.06	0.60	1.24	1.29	0.09	0.55	0.23	0.96	0.56	0.82
Southeast	0.99	0.31	0.66	0.29	1.08	0.72	1.02	0.38	0.40	0.35	0.73	0.44	0.65
Northeast	0.56	0.16	0.30	0.35	0.27	0.40	0.43	0.06	0.24	0.13	0.91	0.40	0.70
North	0.18	0.05	0.09	0.12	0.04	0.08	0.09	-0.02	0.04	0.00	1.11	0.58	1.04
Brazil	6.50	1.84	3.03	4.35	2.84	3.47	3.79	0.69	1.62	0.76	0.90	0.53	0.80

[1] Amount of N fixed by soybeans and common beans.
[2] Source: ANDA (2010 to 2013).

Table 2. Annual nutrient budgets for main crops in Brazil (average of 2009-2012).

Crop	Crop removal[1] N	Crop removal[1] P_2O_5	Crop removal[1] K_2O	Legume fixation[2] N	Nutrient applied[3] N	Nutrient applied[3] P_2O_5	Nutrient applied[3] K_2O	Balance N	Balance P2O5	Balance K_2O	Removal-to-use ratios N	Removal-to-use ratios P_2O_5	Removal-to-use ratios K_2O
	---------- million t ----------												
Soybean	4.30	0.92	1.64	4.30	0.10	1.84	1.66	0.10	0.92	0.02	0.98	0.50	0.99
Maize	0.93	0.51	0.34	-	0.84	0.53	0.52	-0.09	0.02	0.18	1.11	0.96	0.65
Sugarcane	0.58	0.18	0.66	-	0.72	0.25	0.78	0.14	0.07	0.12	0.81	0.72	0.85
Coffee	0.05	0.01	0.05	-	0.36	0.10	0.25	0.31	0.09	0.20	0.14	0.10	0.20
Cotton	0.08	0.03	0.08	-	0.17	0.18	0.14	0.09	0.15	0.06	0.47	0.17	0.57
Rice	0.15	0.06	0.06	-	0.14	0.08	0.07	-0.01	0.02	0.01	1.07	0.75	0.86
Beans	0.11	0.03	0.06	0.05	0.08	0.08	0.05	0.02	0.05	-0.01	0.85	0.38	1.20
Orange	0.04	0.01	0.03	-	0.07	0.03	0.05	0.03	0.02	0.02	0.57	0.33	0.60
Wheat	0.106	0.04	0.02	-	0.11	0.08	0.06	0.004	0.04	0.04	0.96	0.50	0.33

[1] For sugarcane, a 20% deduction was considered for K removal considering the regular disposal of vinasse.
[2] Amount of N fixed by soybeans and common beans.
[3] Source: Cunha et al. (2014).

Brazil, presents an adequate budget of 0.80, mainly a reflection of the high level of regard that farmers continue to have for K within their crop production systems.

Crop Budgets

Nutrient budgets for nine crops grown between 2009 and 2012 are presented in **Table 2**. Nutrient use is higher than crop removal in most crops with the exception of N use in maize (1.11), rice (1.07), and for K_2O in beans (1.20)—all due to low nutrient use in these crops.

Potassium use is most balanced in soybean which has a removal-to-use ratio of 0.99, followed by rice (0.86) and sugarcane (0.85). Almost all crops show low P removal-to-use, but maize, rice and sugarcane are exceptions with values of 0.96, 0.75 and 0.72, respectively.

Coffee has the lowest set of removal-to-use values for N (0.14), P_2O_5 (0.10) and K_2O (0.20). Coffee is traditionally grown with a high level of technology and the crop receives large annual applications of nutrients. However, this study does reveal the need to improve agronomic management in coffee through possible use of crop rotation or cover crops that can promote crop nutrient uptake, reduce losses, and increase nutrient use efficiency.

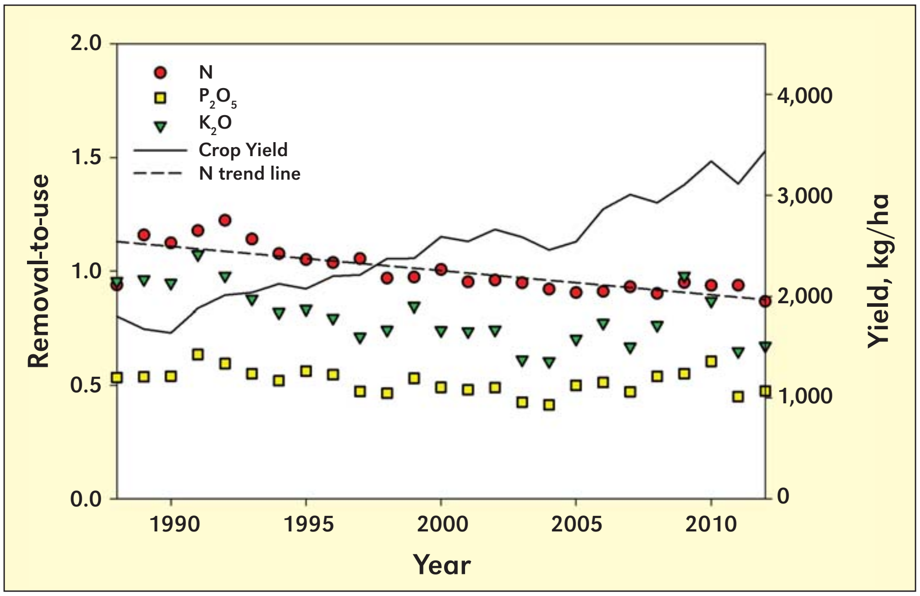

Figure 1. Ratio of N, P_2O_5 and K_2O removal-to-nutrient use by main crops, and average crop yield in Brazil. (Adapted from Cunha et al., 2011).

Looking Further Back

In order to extend this analysis back to represent removal-to-use prior to 2009, trends in N, P and K budgets between 1988 and 2012 are provided in **Figure 1**. The data shows that N removal was higher than N input up until the late 1990s. After this period, N use has increased due to the adoption of more intensive cropping systems with higher inputs, especially for sugarcane, orange, coffee, and maize. The N removal-to-use ratio reached 0.87 in 2012. Phosphorus removal-to-use has essentially remained constant at 0.60. However, K_2O use has behaved similarly to N, following the same increasing use trend towards the current removal-to-use value of 0.67. Potassium showed a dramatic increase in removal-to-use in 2009 (0.98), which reflects a time of economic crisis and a response by farmers to decrease K input to their cropping systems.

The steady growth in nutrient use within this time frame has been effective at improving crop production in Brazil. The annual average yield of Brazilian agriculture, considering the same list of 18 crops mentioned above, is reflected by a steadily ascending line. In 1990, the yield was around 1,700 kg/ha and after 20 years has increased to 3,440 kg/ha in 2012.

Brazilian agriculture has featured high nutrient consumption in support of significant crop production increases over these recent decades. But crop production in this region is also conducted in a vast area of tropical soils with native properties that do not allow adequate nutrient use efficiency without proper agronomic management. Nutrient budgets have been performed periodically to help identify fertilizer use gaps in crops or regions, as well as to forecast future demands. In this

IPNI Photo/E. Francisco

Soybean harvest in Mato Grosso: its production leads nutrient use in Brazilian agriculture.

context, educational initiatives aimed at educating farmers and agronomists on how to assess the best performance of nutrient inputs are crucial to promote fertilizer use efficiency, minimize nutrient loss, and increase crop production sustainability. BC

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