International Section

BRAZIL

Available Phosphorus and Potassium Status of Soils of Amazonas State

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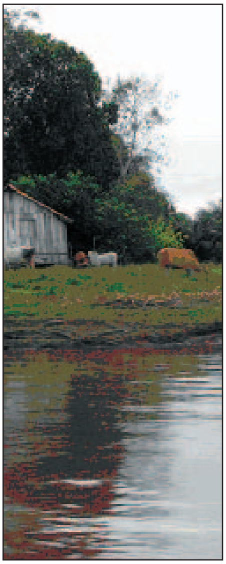

Overview of the Amazonas area in Brazil.

Amazonas State in Brazil does not have significant fertilizer consumption at present, but the area has great potential for production of oil palm and other crops. Researchers recently compiled results from over 3,000 soil samples taken during the last 30 years. They identified large areas of phosphorus (P) and potassium (K) deficiency in soils.

Subsistence agriculture producing cassava, beans, rice, and bananas currently prevails in Amazonas State. The climate and other conditions are favorable for industrial crops such as palm oil, rubber, tropical fruits, and possibly even beef cattle. Agroforestry systems with a crop mix of cacao and rubber or Brazil nut and cacao are being considered.

However, the region has serious limitations with regard to soil fertility. Even where river access to transportation and commercial trade is readily available, fertilizer use is still in its infancy. The slow development can be attributed to lack of affordable crop inputs as well as to inconsistent support for programs designed to promote efficient use of fertilizers and soil amendments. The current low literacy level and difficulty in financing agricultural production are other drawbacks.

About 75% of soils in the tropical Amazon region are either Oxisols or Ultisols. Both soil types are found in the uplands, "Terra Firme", and the floodplains, "Várzea", which comprise the two principle landscapes. The upland topography undulates moderately, having flat and dissected areas, small hills, and narrow valleys located beyond reach of river floods. Soils are acidic and aluminum (Al) toxicity occurs in about 80% of the region. The floodplains encompass 60,000 km^2 and have variable fertility and soil composition due to inconsistent deposition of sediments with varied mineralogical origin, organic composition, and particle size distribution, derived from the Andes Mountains and river bank erosion.

Despite this diversity, soils are predominantly dystrophic, with exchangeable calcium (Ca) and magnesium (Mg) lower than 1.5 cmol$_c$/dm^3 (Moreira and Malavolta, 2002).

Malavolta (1987) and Lehmann et al. (2001) estimate 90% of soils in the Amazonian area have poor fertility. Soil testing commonly finds K, Ca, Mg, and available P to be below critical levels. Available soil P and K are primary yield-limiting factors as judged by the frequency of Mehlich 1 samples testing less than 5 mg/dm^3 for available P and 0.1 cmol$_c$/dm^3 for available K. This is clearly limiting agricultural activity in the central Amazon. Most soils have higher than 50% Al saturation and lower than 50% base saturation. These conditions present a large obstacle for healthy root growth and plant development (Demattê, 1988).

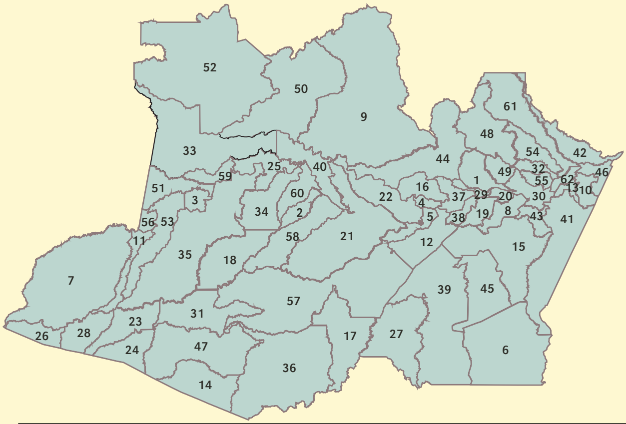

Figure 1. Counties in Amazonas State of Brazil.

With the objective of presenting more substantial data, results from 3,340 soil samples collected during the past 30 years were compiled by the Laboratory of Soil Fertility of the Brazilian Agricultural Research Enterprise (Embrapa Western Amazon—Manaus). Samples were collected from all 62 counties of Amazonas…the largest state in Brazil…with approximately 1.5 million km^2, representing 30% of the Brazilian Amazon area (**Figure 1**). In the absence of geographical coordinates, it was assumed that sample points were uniformly scattered over each county. Soil fertility data were assembled as three intervals of percent frequency with 0 to 40%, 40 to 80%, and 80 to 100% of occurrences below 5 mg/dm^3 for available P, and 0.1 cmol$_c$/dm^3 for available K.

Results of the Survey

Western and central counties with large areas near sediment-filled rivers, or lakes flooded by these rivers, had the lowest occurrence of soil P deficiency (**Figure 2a**). A few soils in the central region were identified as isolated areas of higher P fertility. Given their location (i.e., Anori, Careiro da Várzea, Alvaraes, Uarini, and Juruá counties), they are most likely examples of floodplain or anthropogenic soils. The loamy plains in the eastern and western part of central Amazonas had intermediate P fertility.

Counties located inside a wide arch extending north to south had more than 80% of samples testing low in available P. The low values observed in

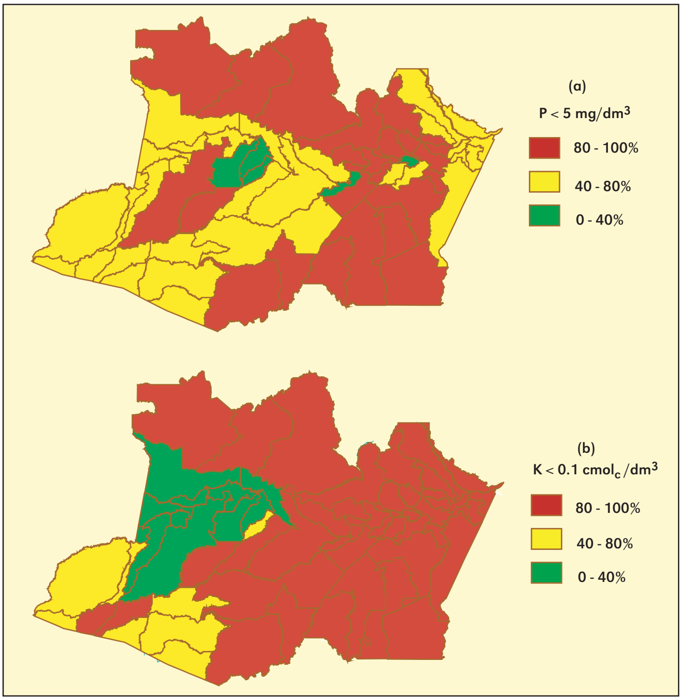

Figure 2. For Amazonas State, frequency of highly P-available deficient soils (< 5 mg/dm^3) is illustrated at top (a). Frequency of highly K-available deficient soils (< 0,1 cmol$_c$/dm^3) is illustrated in (b). Mehlich 1-extractable P and K (N = 3,340 samples).

the northern reaches of the state are a result of extensive plateau areas covered by higher weathered sediments of the cretaceous-quaternary period, and of crystalline shield uplands located around the basin of blackwater rivers (i.e., Negro, Japurá, and Branco Rivers) characterized by an absence of sediment. The counties of this area (Barcelos, Santa Isabel do Rio Negro, São Gabriel da Cachoeira), together with the entire east and a large part of central Amazonas (Carauari and Jutai), represent 70% of the state wherein 80 to 100% of soil test P values were less than 5 mg/dm^3.

With regards to available soil K, the western reaches had the lowest occurrence of samples testing below 0.1 cmol$_c$/dm^3 (**Figure 2b**). These relatively high K contents are mainly a result of an appreciable presence of primary minerals such as feldspars, chlorite, and micas (Marques et al., 2002). In the extreme west and southwest, 40 to 80% of samples tested below 0.1 cmol$_c$/dm^3. It was verified that the central and eastern areas of the state represent a large block of K deficiency. This area along with the equally K-deficient northern counties (Barcelos, Santa Isabel do Rio Negro, São Gabriel da Cachoeira) combine to represent 70% of the state wherein a vast majority of samples (80 to 100%) tested less than 0.1 cmol$_c$/dm^3. BC

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