Replenishment of C, N, and P in A Degraded Alfisol Under Humid Tropical Conditions: Effect of Fallow Species and Litter Polyphenols

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Abstract

The capacity of vegetation fallow to replenish carbon and nutrients in degraded soil is related largely to the nature of the fallow vegetation, particularly the chemical composition. Therefore, a study was conducted at Ibadan, southwestern Nigeria (humid tropics), to look into these relationships using fallow species with varying chemical compositions. The treatments include three woody species,Senna siamea, Acacia leptocarpa andLeucaena leucocephala, planted in 1989, and the natural shrub Chromolaena odorata.A continuous cropping of maize/cassava was maintained as a control (no fallow). Composite surface soil (0-15 cm) at three distances from a tree hedgerow (0.5, 2.0, and 3.5 m) was sampled in 1996 for the determination of soil C and nutrient stocks. Maize and cassava were planted as a test crop of soil productivity after fallowing. Litterbags were placed to determine the N immobilization during the decomposition of fallow leaves. Soil organic C (SOC) within 0-15 cm ranged from 19,100 (continuous cropping) to 26,400 kg ha-1 (Leucaenafallow), whereas total N ranged from 1820 (continuous cropping) to 3110 kg ha-1(Leucaena fallow). High polyphenols in fallow leaves favored SOC and N accumulation. The amount of potentially mineralizable N was increased from 41 kg ha-1 in continuous cropping to 159 under Leucaenafallow and 176 under Acacia fallow. The percentage increase in mineralizable N stock under fallow was, on average, 5.5 times greater than that in total N, implying that fallow causes change in soil organic matter quality. The available P (Olsen) was 8.6 kg ha-1 in the continuous cropping and ranged from 14.1 kg ha-1 (natural fallow) to 29.2 kg ha-1 (Leucaena fallow). Greater maize and cassava yields were obtained in the fallow plots than in the control during the subsequent cropping. The maize grain yield after fallow could be predicted by the potentially mineralizable N in surface soil (0-15 cm). Leucaena and Acacia are promising species for planted fallows for soil regeneration in the humid tropics. The binding of protein by polyphenols during leaf decomposition, as confirmed by higher N immobilization with the increase in leaf polyphenols, could be the main mechanism in the contribution of polyphenols to SOC and N replenishment in the degraded soil. The study suggests the possibility of stabilizing C and N in tropical ecosystems by manipulating polyphenols in vegetation.

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