ORGANIC MATTER DYNAMICS AFTER CONVERSION OF FORESTS TO FOOD CROPS OR SUGARCANE: PREDICTIONS OF THE CENTURY MODEL

S.M. Sitompul[1], Kurniatun Hairiah[2], Meine van Noordwijk[3] and P.L. Woomer[4]

Department of Agronomy (1) and Soil Science (2), Faculty of Agriculture, Brawijaya University, Jl. Veteran Malang 65145, Indonesia
(3) ICRAF-S.E.Asia, P.O.Box 161 Bogor 16001, Indonesia,
(4) Tropical Soil Biology and Fertility (TSBF), Nairobi, Kenya

ABSTRACT

The major constraints of acid upland soils such as ultisols when used for agricultural purposes are the rapid degradation in its fertility and the limited and highly variable supply of water. Slash and burn methods for land clearing are used both in the traditional cropping system with low-input management on such soils and for conversion of forests to perennial crop plantations. The primary objective of the present study was to simulate soil organic matter (SOM) dynamics after converion of forest by slash and burn methods to food crops or to a sugarcane estate. A comparison is made between sugarcane as managed by of Bungamayang Sugar Plantation (BSP) in Lampung applying high-input management and by smallholders in the area, who often do not use fertilizer. The CENTURY model version 3.0 was used to simulate the SOM dynamics on the basis of site files for shifting cultivation in Sumatra. The results of simulation were compared with observations on SOM dynamics on an Ultisol in the study area.

Predicted SOM dynamics vary substantially between vegetation, crop management and fractions of SOM. Forest removal followed by rice or sugarcane cultivation causes a considerable decrease in active (SOM1C), slow (SOM2C) and total soil carbon (SOMTC) particularly with farmer management. When BSP management is followed by the application of straw, the decrease in SOM is markedly reduced. Nearly similar results are found when biological management (zero tillage + P fertilizer + straw) is applied. The most sensitive SOM pool in response to changes in vegetation and soil is SOM1C followed by SOM2C, whereas SOM3C (passive soil C) declines only slightly with time in all cases. The dynamic of SOMTC, the most frequently measured SOM pool, can be used in most cases to represent changes in SOM2C, but not SOM1C or SOM3C. Crop yield declines drastically in the second year with farmer management. Sufficiently high yields can be expected for sugarcane in the first ten years with BSP or biological and particularly BSP + straw management, but declines are to be expected thereafter. The model predicts a clear role for SOM in the maintenance of cane productivity on the Ultisol in Lampung, acting directly as well as through N and P supply.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is widely cultivated now on acid soils in Indonesia. For instance, the total area of sugarcane in Lampung, where soils are dominated by Ultisols, was estimated to be more than 100,000 hectares (Ismail, 1990). Some of this area was under primary (logged-over) or secondary forest vegetation prior to its conversion to sugarcane plantation by slash and burn techniques. After ten years of cultivation following forest removal, sufficiently high cane yields were still reported in the sugarcane estate of Bungamayang sugar plantation (BSP). This suggests that declining soil fertility, the central issue on acid soils, is not (yet) a constraint to sugarcane production. The sugarcane estate operates with high-input management involving lime and high fertilizer rates, while sugarcane is highly tolerant to aluminium and low pH. Sugar cane has a sufficiently dense canopy during the last one-third of the growing season. Successful plantation of sugarcane on acid soils was also reported in Australia without serious problems, except deficiencies in calcium and magnesium which were corrected with application lime (dolomite) and Mg-fertilizer (Edwards and Bell, 1989).

The application of lime and fertilizers alone, which have been found to be effective to tackle the infertility of acid soils in many cases (McIntosh & Effendi, 1979; Setijono & Soepardi, 1985; Ismunadji & Makarim, 1989), will not be able to alleviate the deteriotation of soil fertility due to decline in SOM and erosion. Sanchez (1983) reported that frequent lime application was needed (every one to three years) to maintain high yields of upland rice, maize, soybean and peanut on an acid soil at Yurimaguas. He also found that the quantity of fertilizers and lime required to eliminate soil constraints varied between adjacent fields having the same previous vegetation, geomorphic position and soil classification at family level. Smallholder farmers in North Lampung often do not use fertilizer on their sugar cane (partly due to logistical problems in fertilizer supply via BSP) and many farmers do not continue growing sugarcane after the first crop cycle. Serious difficulties exist for the adoption of high-input technologies for small farmers.