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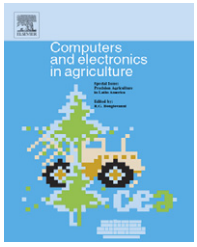

Simulating plant productivity under different organic fertilization practices in a maize/native pasture rotation system in semi-arid NE Brazil

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ABSTRACT

Subsistence agriculture systems in semi-arid regions need to adapt management to rainfall variability within the constraints of low-cost alternatives. Organic fertilization is generally the best possible option to maintain soil fertility as the use of chemical fertilizers is unfeasible due to the high cost and risks of drought and crop failure. However, the effectiveness of organic fertilization will vary according to the quality and rate of organic fertilizer application, rainfall scenarios and decomposition patterns. Simulation models can be used for a quick evaluation of management strategies in many possible scenarios. In this paper a newly developed model (SALSA: Semi-Arid Latin-america Simulation model for Agroecosystems), was used to simulate, along a 3-year period, plant productivity and soil fertility in a maize/native pasture rotation system in semi-arid NE Brazil. The model simulated reasonably well the observed maize productivity in the experimental plots during the 3 years of the study, even under contrasting rainfall conditions and application of organic fertilizers of different qualities (animal manure or *Gliricidia sepium* prunings). However, model simulations of native pasture biomass productivity did not adequately represent seasonal and fertilizer responses, in part probably due to the seasonal variability of the pasture species composition. The model showed that the effectiveness of organic fertilization depended upon rainfall with largest response in years with intermediate precipitation, and lower responses in wet and dry years. High nitrogen leaching and cloudiness reduced fertilizer use efficiency in wet years even at high rates of fertilizer application (20 t ha^{-1}). Fertilization with *G. sepium* did not increase aboveground maize productivity compared with animal manure, even though it contained twice the amount of labile fraction. This lack of crop responses to a more labile fertilizer is explained by the large fraction of nitrogen that is leached to deep soil which reduced nitrogen availability in the volume of the soil with the largest amount of crop roots. Management strategies that reduce nitrogen leaching or favor pumping nitrogen from deeper layers (agroforestry) would benefit productivity in this system. The SALSA model proved to have potential as a useful tool to help decisions needed to increase organic fertilization efficiency in NE Brazil even though the base information is scarce compared with modern agriculture.

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1. Introduction

Agricultural activities in the semi-arid region of northeastern Brazil are based on the cultivation of subsistence crops, such as maize, beans and cassava, and the production of meat and milk by cattle, goats and sheep. Commonly, after grain harvest within agricultural fields, crop residues are fed to the livestock and the native vegetation is allowed to grow to be used as pasture during the dry-season. The main soil types in the region are Alfisols and Entisols, and most soils are shallow and poor in fertility, particularly regarding N and P availability (Sampaio et al., 1995). Chemical fertilizers are rarely used by farmers, due to high cost and frequent droughts which increase the risk of crop failure (Sampaio et al., 1995). Therefore, soil fertility maintenance depends mostly on management of soil organic matter (Tiessen et al., 1994). Animal manure is commonly used as fertilizer, however the amount of manure accumulated in corrals or collected by farmers is not enough for all cropped fields. In addition, the manure available to farmers is usually of poor quality, with low nitrogen and high recalcitrant carbon contents (Silva and Menezes, 2007). Recently, green manure practices have been suggested as a low-cost organic nutrient source. *Gliricidia sepium*, a fast-growing, drought resistant legume tree native to Central America, has been introduced for providing high quality forage, and nutrient rich, labile green manure (Marin et al., 2007). However, the high lability of *G. sepium* manure may increase soil nitrogen availability for just a short period. During years of intense rainfall at the beginning of the growing season, drainage to below rooting depth may leach the released nitrogen before crop uptake takes place. Moreover, it is unlikely that nitrogen added as green manure would have a residual effect in subsequent years. Therefore, the effectiveness of types and rate of fertilizer would vary according to rainfall conditions.

There is growing demand for adequate land use decisions criteria that maintain productivity without increasing negative impacts on ecosystem properties (Tilman et al., 2002). Management changes are limited because desirable agro-ecosystem properties are difficult to maximize as they are usually negatively correlated. Simulation modeling has become a promising tool to study complex systems and different attempts have been done to use modeling to predict land-use outcome when using organic sources of nutrients (Zhang et al., 2002; Koopmans and Bokhorst, 2002; Cavero et al., 1998). Site-adapted models can be used to anticipate consequences of climate variability under different management strategies, as long as such models are adequately validated to the target systems (Walker et al., 2007). However, crop simulation models are usually difficult to apply in low technological agricultural systems. These models represent processes with large details and therefore they demand a large amount of information to define driving variables and parameters. There is a need for site-adapted models that represent process at an intermediate scale (mesoscale), which is the scale of interest of most land use and sustainability issues in many subsistence agriculture areas worldwide.

This paper describes the SALSA model (Semi-Arid Latin-America Simulation model for Agroecosystems), which is being developed to represent different management practices with an intermediate level of resolution. SALSA was used here to define the most adequate fertilization strategy in a maize/native pasture rotation system according to the forecasted rainfall year in the semi-arid region of northeastern Brazil.

2. Material and methods

The SALSA model is driven by monthly weather and represents a cultivated plot at monthly or weekly resolution depending upon processes. The model simulates soil water, soil carbon and nitrogen, and plant growth in a plot that is considered as a homogeneous unit of production (Fig. 1). Plant

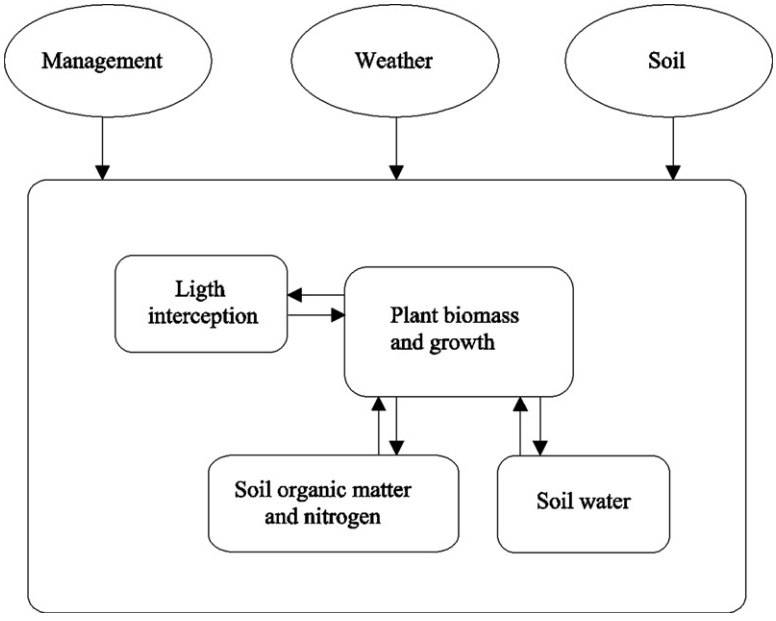

Fig. 1 – Main driving variables (ovals), and simulated processes (boxes) of the SALSA model.