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Characterizing the constraints for the adoption of a *Callopogonium mucunoides* improved fallow in rice production systems in northern Ghana

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Abstract

In northern Ghana, rice (*Oryza sativa*) production is limited by nitrogen deficiency. Farmers cultivate rice fields almost continuously with little or no nutrient inputs. The traditional natural fallow periods are too short to restore soil fertility and farmers cannot afford or access chemical fertilizers. Results from some studies suggest that incorporating leguminous cover crops into short duration fallows can improve subsequent crop productivity. The objective of this study was to compare an improved fallow of a leguminous species, *Callopogonium mucunoides*, with traditional practices of natural bush fallow and continuous rice cropping on rice yields, profits and risk efficiency in the Tolon-Kumbungu district of northern Ghana. The *C. mucunoides* improved fallow proved superior to the two other cropping practices but the superiority diminished after 2 years of cultivation suggesting a 2-year cropping cycle in line with the existing system. An ex-ante assessment of the adoption of the improved fallow system by farmers identified crop residue incorporation and cost of inputs as major constraints. This suggests the identification and use of an alternative cover crop with similar soil amelioration properties as *C. mucunoides* but less demanding on labor for incorporation.
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1. Introduction

One of the key limiting factors to agricultural production in West Africa is declining soil fertility resulting from frequent use of the land without adequate replenishing of lost nutrients (Tarawali et al., 1999; Dogbe et al., 2000). A balanced alternation between periods of cultivation and fallow is one of the few realistic ways of maintaining farmland productivity among the peasants of tropical Africa (Young and Wright, 1979). Unfortunately, natural bush fallowing and shifting cultivation primarily to restore soil fertility can no longer be sustained due to increasing human and livestock population pressures (Tarawali et al., 1999; Okigbo, 1990). Removal of subsidies on chemical fertilizers has resulted in a wide

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gap between current levels of chemical fertilizer use and the required level mainly because most farmers can no longer afford chemical fertilizers due to high cost (Gerner et al., 1995; Donhauser et al., 1994). The use of animal manure, as an alternative to chemical fertilizer is constrained by inadequacy, transport and labor costs (McIntire et al., 1992; Langyintuo and Karbo, 1998). Cover cropping and surface residue restitution have the potential for minimizing the loss of nutrients and soil organic matter in the savannah regions of northern Ghana (Rhodes, 1995) since natural bush fallow periods are too short for rejuvenating the soil before subsequent cropping sequences (Langyintuo, 1989; Donhauser et al., 1994). Rice fields are often fallowed for an average of 2 years (Donhauser et al., 1994; Langyintuo, 1998a).

The length of a fallow period and the type of fallow vegetation can affect the rate and extent of soil productivity regeneration. For example, improved tree fallows have great potential for improving soil fertility in areas dominated by N deficiency (Kwesiga and Coe, 1994; Kwesiga et al., 1999). Leguminous cover crop fallows can contribute to soil N (Tarawali et al., 1999), soil organic matter (Tian et al., 1999), soil physical properties (Wilson et al., 1982), and improve crop yield (Tian et al., 1999, 1997). Research institutes in sub-Saharan Africa, such as the International Institute of Tropical Agriculture (IITA) in Nigeria and the West African Rice Development Association (WARDA) in Côte d'Ivoire, have developed and emphasized the use of various leguminous fallow systems to replace natural vegetation fallow (Sanchez, 1995; Tian et al., 1999). Short duration, improved fallows are among alternative farmland management strategies that have evolved (Tarawali et al., 1999) to improve soil productivity. Studies have ascertained the potentials of such managed fallows to soil fertility replenishment in several countries in sub-Saharan Africa (Batiano and Mokwunye, 1991; Mittal et al., 1992; Kwesiga and Coe, 1994; Mafongoya and Nair, 1997; Kaya et al., 2000). Nevertheless, several authors (Tarawali et al., 1999; Franzel, 1999; Place and Dewees, 1999) have reported that adoption rates for such fallows are low due mainly to socioeconomic and policy issues. The potential profitability and risk efficiency of systems that incorporate cover crops may not be fully understood except in a context that takes into consideration the insights of farm operators and their managerial, labor, and capital requirements.

The Savanna Agricultural Research Institute (SARI) in Ghana in collaboration with WARDA developed an improved fallow system which incorporates a leguminous cover crop, *Callopogonium mucunoides*, into natural bush fallow for rice production systems. It was tested on-farm between 1992 and 1996 alongside natural bush fallow and continuous rice production in the Guinea savannah soils in the Tolon-Kumbungu district in northern Ghana where 70% of the domestic rice is produced. This study was designed to (i) evaluate average rice yields and the risk-efficient choice a farmer would select to maximize household food self-sufficiency, (ii) evaluate the income risk-efficiency associated with the three rice cropping systems, and (iii) examine the potential for adoption of the improved fallow system by farmers in northern Ghana. Although the study is limited in scope, the results and study method is applicable to similar resource-limited farming systems in the tropics.

2. Methodology

2.1. Study area

The Tolon Kumbungu district of northern Ghana lies between latitudes 8°30′N and 0°30′E. It is in an undulating plain with an altitude of 100–200 m above sea level. It has a distinct rainy season from May to October with a mean annual rainfall of 1100 mm and a dry season from November to April. Mean annual temperature range is 27–28 °C. Situated in the voltaian sandstone basin, the parent materials are the savannah glycols and savannah Ochrosols (FAO Ferrasols and Acrisols). Kaolinite and illite are the main clay minerals. Soils are usually well drained and provide no limitation to vertical root development but because of prevailing clay minerals and low organic matter content, the water storage and cation exchange capacities are very low (Donhauser et al., 1994).

Population densities range from 51 to 100 persons/km^2. Farm sizes range from 3 to 20 ha with a mean of 9.2 ha. Crops commonly grown are rice, sorghum (*Sorghum bicolor*), millet (*Pennisetum typhoideum*),

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