Comparative evaluation of labour use and profitability of soil fertility replenishment practices in southern Africa

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Abstract

Soil fertility degradation is a major threat to food production in sub-Saharan Africa. in response, a number of practices based on biological nitrogen fixation and nutrient cycling principles have been developed to assist smallholder farmers improve their soils but, information on the labour use requirements and profitability of these practices has been lacking. This study compared the labour inputs and financial profitability of maize production with and without fertilizers, and different agroforestry practices in eastern Zambia. The results did not support the notion that agroforestry practices are more labour intensive than monoculture maize. With Net Present Value (NPV) ranging between \$233 and \$309 ha^{-1}, agroforestry practices were more profitable than *de facto* farmers' practice (continuous maize production without fertilizer) which yielded an NPV of \$130 ha^{-1}. Although fully fertilized fields was superior to agroforestry practices, the difference in profitability of chemical fertilizer subsidized at 50% over agroforestry practices decreased from 61 to 13%. The return to labor per person day was \$3.16 in subsidized fertilized fields, \$2.56 in non-subsidized fertilized maize, and between \$2.55 and \$1.90 for agroforestry practices. The figure in in unfertilized maize fields was \$1.10. Price of maize grain, labour wage rate and cost of fertilizer exerted greatest influence on the financial profitability (and hence potential adoptability) of land management practices.

Keywords: *Agroforestry, Benefit Cost Analysis, Fertilizer Subsidy, Net Present Value, Sustainable agriculture*

1. Introduction

There is a general consensus in the literature that soil degradation is a major threat to food production Sub-Saharan Africa (SSA) and, that this problem is often linked to food insecurity and poverty (Sanchez, 2002; Vanlauwe and Giller, 2006). The situation arises due to the breakdown of the long fallow system that farmers have used for centuries to replenish the fertility of their soils and the use of little or no fertilizer because they are not affordable or accessible to the majority of smallholder farmers. In response to these challenges, the World Agroforestry Centre (ICRAF) and partners in the early 1990s began a search for sustainable options that are affordable for resource-poor farmers to replenish their soils within 2-3 years unlike the traditional fallow systems that take up to 15 years. The search led to the development of an agroforestry practice called "improved tree fallow". This practice involves the planting of fast growing trees or woody shrub species that fix nitrogen. Species such as *Sesbania sesban*, *Gliricidia sepium* and *Tephrosia vogelli* fix atmospheric nitrogen which can be made available to crop by pruning the leaves and twigs and incorporating these in the soil to enhance crop yield. There is growing evidence that these practices are technically sound (Kwesiga et al., 2003; Akinnifesi et al., 2006; Mafongoya et al., 2006; Sileshi et al., 2008) but, apart from few studies (Place et al., 2002; Franzel, 2004), there is information gap on the economics of labour inputs of the improved tree fallows relative to conventional soil fertility replenishment practices. This study was set up to quantify the labour inputs of "improved tree fallows", and compares the profitability and returns to investment of different soil fertility replenishment options.

2. Materials and methods

This study compared the labour inputs and financial profitability of maize production using different agroforestry practices with maize production with or without commercial fertilizer in eastern Zambia. Two scenarios were considered for commercial fertilizer use: 50% government subsidy and no subsidy. For this analysis, agro-economic data collected on multiple visits from 89 fields in eastern Zambia in 2002/2003 season were used. Farmers were selected based on stratified sampling technique. To minimize problems associated with data obtained from long memory recall and yet do so at relatively low cost, we gave all the farmers that participated in the study a notebook on which they (or their literate children) recorded information on the farm activities, details on all inputs they used for all operations in the field (activity, duration and number of workers, costs) and the outputs (yield, value) that they got from the same. A research technician made a summary of the information on farmers' field notes and entered the same into a weekly data sheet. The sizes of the fields selected for the study were measured using a Geographical Positioning System equipment.

3. Results and discussion

Land preparation, weeding and harvesting field operations alone accounted for over two-thirds (70%) of all labour used in the maize fields. Almost all the labour (90%) was provided by household members while hired labour contributed less than 10% and, rotational group was almost nil. Aggregated over a five-year period, the quantity of labour used in "improved tree fallows" was lower than that in fields where fertilizer was applied. The lower labour use was due to lower maize yield recorded in improved tree fallow fields than for mineral fertilized field which imply a lower labour requirement for harvesting.

Table 1: Labor inputs use (person-days ha^{-1}) in different land use systems in Zambia

Type of land use system	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Continuous, no fertilizer	104	95	88	88	87	462
Continuous, with fertilizer	110	121	101	103	97	532
Gliricidia sepium fallow	130	2	132	125	45 *	389
Sesbania sesban fallow	111	45	128	121	116	521
Tephrosia vogellii fallow	105	40	118	117	113	493

The results did not support the popular belief that agroforestry practices are more labour intensive. Similar results were reported by Franzel (2004) who estimated that labour use in improved tree fallow fields was 11% lower than that of fertilized maize fields. Labour constraints in improved tree fallow fields may be due to the competing demand for labour in other crop fields such as cotton and groundnut. Farmers' innovations (modifications to the agroforestry practice) that farmers carried out through "learning by doing" (Kwesiga et al., 2005; Katanga et al., 2006) probably contributed to the low quantity of labour used by farmers in improved tree fallow fields. The average area cultivated by farmers to improved fallow is also small (0.2 ha) and so easy for households to provide the additional labour required on this “new” type of field. The ability of households to continue to provide such extra labour to manage trees will become more important as more farmers adopt the practice and or as the average size of land put under improved fallow increases in the future.

The profitability of soil management options over the study period is shown in Table 2. With the Net Present Value (NPV) ranging between $233 and $309 per ha, agroforestry practices were more profitable than *de facto* farmers’ practice (continuous maize production without fertilizer) which yielded an NPV of $130 ha^{-1}. However, agroforestry practices were less profitable than subsidized fertilizer, which yielded a NPV of $499 ha^{-1} and non-subsidized mineral fertilizer which had an NPV of $349 ha^{-1}. However, in terms of returns per unit of investment, the three variants of improved tree fallows are financially more attractive than continuous maize production with or without fertilizer. The reason is because the higher net profit obtained in the fertilizer field was achieved through a higher investment cost.

Table 2: Profitability of soil fertility management options over a five-year cycle

Description of system	Net Present Value (US $/ha)	Value to Cost Ration
Continuous maize for 5 years without fertilizer	130	2.01
Continuous maize for 5 years with fertilizer (non subsidized)	349	1.77
Continuous maize for 5 years with fertilizer (subsidized)	499	2.65
2 years of Gliricidia fallow followed by 3 years of crop	269	2.91
2 years of Sesbania fallow followed by 3 years of crop	309	3.13
2 years of Tephrosia fallow followed by 3 years of crop	233	2.77

Figures based on prevailing costs & prices and an annual discount rate of 30%

When the 50% subsidy on fertilizer was factored into the analysis, the results show that the difference between the profitability of mineral fertilizers over agroforestry practices decreased from 61to 13%. The return to labour per person day was $3.16 in subsidized fertilized fields, $2.56 in non-subsidized fertilized maize, $2.41 for *Sesbania sesban*, $2.55 for *Gliricidia sepium*, $1.90 for *Tephrosia vogelli* and $1.10 in unfertilized maize fields. These returns compared with a daily agricultural wage rate of $0.60 in the study area. The key production factors that affect the profitability (and expectedly potential adoptability) of the different land use systems were price of maize grain, cost of capital, labour wage rate and cost of fertilizer. These four items are the most influential determinants of the financial attractiveness of maize production for the various soil fertility options.

4 Conclusion

The degradation of soils through loss of soil organic matter characterizes many unsustainable agricultural systems. For a long time, several attempts have been made to solve this problem through sustainable land use management practices. One of such practices is improved tree fallows that developed and promoted in southern Africa. The popular notion of "labour constraints" in improved tree fallow fields may be attributed to the timing of labour demands and not higher *absolute* quantity of labour use as there is no conclusive evidence that improved tree fallows require more labour per unit cultivated area compared to continuous maize production systems with fertilizer. Improved tree fallows are more profitable than continuous maize production without fertilizer. There are opportunities for improved tree fallow to make great impacts on food security among smallholder households if they are properly targeted to their geographic and social niches.

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