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Financial efficiency of improved fallow agroforestry technology for bean production in Kakooge Sub-county, Nakasongola District, Uganda

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Abstract

The incidence, intensity and effects of nematode infection in the Nile tilapia, Oreochromis niloticus, in Lake Wamala and their biological characteristics, were investigated. Six hundred and thirty fish were examined using standard techniques and found to harbour nematodes belonging to the genus Contracaecum. The parasites were found concentrated in the pericardial region. The incidence and intensity of infection increased with the length of the host besides and it correlated with the onset of maturity of the host. Factors responsible for the variation in the prevalence of the helminths , intensity of infection and their implications are discussed.

Introduction

Past studies by Denning (2001); Byerless *et. al*., 1982; Franzel *et. al*., (2002), have shown that improved fallow agroforestry technology has been promoted as a practical and beneficial land-use system for small holders in developing countries. Multipurpose trees such as *Calliandra calothyrsus, and Sesbania sesban* have been introduced to solve the problems of reduced soil fertility since they are active Nitrogen fixers, and firewood and fodder since they are fast growing and have good coppicing ability (Franzel *et. al.,* 2002). By 2000, some farmers in various ecological regions of the tropics had adopted various improved fallow agroforestry technologies, which is a good indicator that the technologies are viable for tropical countries (Denning, 2001).

The arable soils in Uganda are no longer able to provide enough nutrients to achieve sustainable crop yields (Siriri and Bekunda, 2001). Consequently, yields of beans, the staple food crop for the majority of people, have been declining throughout the country (Raussen, 1998). In Uganda, about 85% of the population are peasant farmers living in the rural areas, which are the main stay of agricultural production (MAAIF, 2001). These farmers operate on smallscale with farm holdings of 1 - 2 hectares, which are usually scattered over a wide area. About 75% of Uganda's land is under arable cultivation with land-human ratio of 58 persons per square kilometre in Central Uganda (UHDR, 2000). This shows that the average size of farmlands are very small and the food production per capita is declining due to reduced soil productivity attributed to nutrient removal through harvesting of crops and soil erosion (Siriri and Bekunda, 2001).

In response to the problem, a number of soil conservation and fertility replenishment measures have been developed and promoted, including agroforestry technologies. Agroforestry has the potential to make long- and short-term contributions to farm production. Studies in several parts of Africa and beyond have demonstrated the economic and agronomic returns of agroforestry practices such as short-term improved fallow (Franzel *et al*., 2002).

An improved fallow is a system where short duration multipurpose trees and shrubs (MPTS) or herbaceous legume species are grown in rotation with cultivated crops to mitigate soil fertility decline. The improved fallow system is emerging as one of the most promising alternative farming systems for eastern, central and southern Africa in terms of soil fertility replenishment, land rehabilitation and increased farm productivity particularly in the beans-based cropping systems (Jama *et. al*., 1997). Studies conducted in Kenya, Tanzania and Rwanda have shown that short-term improved fallow technology increases bean yields per unit area of land. Adesina *et. al*., (2000) reported that improved fallows result in as much as 70 % economic returns per unit area of land compared to fully fertilised bean crop. Franzel *et al (*1998) reported agronomic returns as high as 90% compared to a fully fertilised bean crop. Mugendi *et. al.,* (1999) reported a general increase from 600 kg ha^{-1} of non-fertilised hybrid beans to about 3000 kg ha^{-1} grain yield resulting from intercropping with *Calliandra calothyrus*.

Related studies conducted in Kenya, Tanzania and Rwanda have shown that the short-term improved fallow technology increases beans yields per unit area of land (Swinkel *et al*., 1994; Mugendi *et. al*., 1999). Secondly, *calliandra* -based enterprise yielded a number of benefits to the society which are often difficult to quantify and therefore excluded from the financial analysis.

The overall objective of this study was to examine the financial performance of the short-term improved fallow agroforestry technology for bean production under smallholder farmer conditions in Nakasongola District of Uganda. The specific objectives were to: assess the economic viability of fallow system; identify the sources of revenue for farmers practicing improved fallow agroforestry; and compare the economic returns from *Calliandra* fallow option with the full-fertilised beans production system.

Methods

Study area description

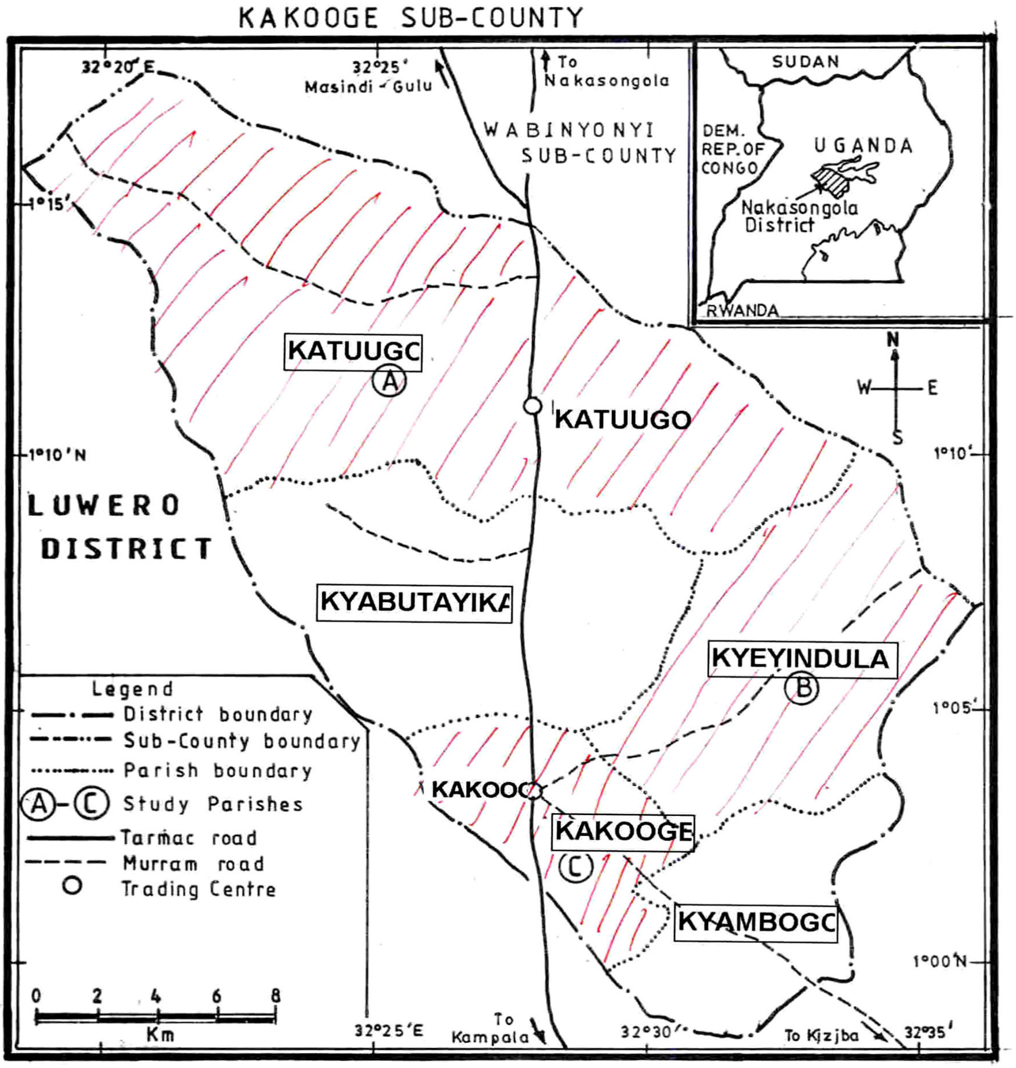
Nakasongola District is located on the Bombo - Gulu highway 114 km north of Kampala. According to NEMA (2001), the district covers an area of 3,424 km^2 of land and boarders with Apac district in the northeast, Mukono district in the east, Masindi in the west and Luwero district in the south (Figure 1) . The area lies on the central plateau between 1,000 and 1,400 m above sea level. The topography is characterized by extensive uniform undulating plains with broad seasonal swamps.

The soils are mainly weathered basement complex formations of the precambrian age, which consists mainly of metamorphic and igneous rocks, largely composed of gneisses and granites. Remnants of the older mid-tertiary surface are found as relic murram and iron stones in some places.

The annual rainfall varies from 875 – 1120 mm with two marked dry seasons and the average temperature ranges between 22.6^0 C to 24.6^0 C. The main vegetation types are woodland and woodland savanna, and thicket consisting of mainly *Accacia-Combretum* continuum associated with *Hyperheria.* Much of the cultivated land exists as patches with in the woodland (Oluka *et. al*., 2000).

According to UBOS (2002), the district has a total population of 528,126 people, the population density is about 230 persons per km^2, and the growth rate is 2.7 %. There are three ethic groups; the Baganda (70%) and Baruli (28) and others (2%). Subsistence agriculture is the major economic activity employing about 89% of population.

Figure 1. Map of Kakooge Sub-county showing the study parishes.



Data collection

The study was designed to facilitate financial evaluation of improved fallow agroforestry technologies through on-farm experimentation. Twenty researcher-designed and farmer-managed on-farm trials were conducted from April 2001 to September 2003 in Katuugo, Kyeyindula and Kyabutayika parishes in Kakooge Sub-county, Nakasongola district. Hybrid bean variety MCM 5001 planted at 75 cm x 90 cm was used as the test crop. The four treatments were beans without fertiliser (control) hereafter referred to as zero input bean production (ZIBP), beans with full fertilizer (both basal and top dressing) (FFBP), beans after *Calliandra calothyrsus* fallow (CCBP) and beans after *Calliandra* fallow with top dressing fertilizer also called mixed input beans production, (MIBP). Calcium of Ammonium Nitrate (CAN) and 23-21-0+4S were applied as top and basal dressing, respectively. In the FFBP plots, basal fertilizer was applied at the rate of 180 kg ha^{-1}. Top dressing fertilizer was applied at the rate of 120 kg ha^{-1} which provided 42 kg N ha^{-1} in both the FFBP and MIBP plots.

Each of the four treatments represented a potential or an already available beans production option. The labour and yield data were collected periodically throughout the cropping seasons. The labour data were collected through recall during periodic field visits.

Data analysis

Financial analysis was performed using enterprise-budget analysis and cost-benefit analysis. In enterprise-budget analysis, each treatment was considered as a separate enterprise. Enterprise budget analysis involved the calculation of gross margins for each of the four beans production enterprises. Although it is valid to compare a stream of costs and benefits of an enterprise over time as above, it is assumed that the farmer is indifferent between current and future consumption (Gittinger, 1982). In order to take into consideration the farmers' preferences regarding when consumption should occur, cost benefit analysis was applied because it uses a discount factor to measure the stream of benefits and costs overtime.

The financial analytical technique was used to evaluate the investment worth of improved fallows for beans production. The Net Present Values (NPV) calculated at a 15 % discount rate and benefit-cost ratio (BCR) to show the cost of production relative to the value of returns of an enterprise were calculated for each enterprise (Upton, 1987). The benefit-cost ratio is calculated by taking the present worth of the gross benefit stream and dividing this by the present worth of the cost stream. Using the equation:

$$NPV = \sum_{t=0}^{t=n} \frac{(Rt - Ct)}{(1 + r)}$$

Where: R_t is discounted revenue; C_t is discounted costs; r is discount rate and t is the enterprise's season.

An enterprise is regarded as profitable if its NPV is positive and BCR greater than 1 (BCR > 1). An improved fallow technology can be accepted if the NPV of net incremental benefits is positive. All projects with a benefit-cost ratio equal to or greater than 1. If the benefit-cost ratio is lower than 1 are accepted, it means that the project yields less benefits than costs and therefore not worthy of capital investment. The selection criterion is to accept all fallow technologies with a benefit-cost ratio equal to or greater than 1. If the benefit-cost ratio is lower than 1, it would mean that the project yields less benefits than costs (in present values).

All cash flows (costs or benefits) were assumed to take place at the end of year. This means that any cost or benefit that occurred during the year was discounted for the entire year. This assumption introduces a small error since actual expenditures or receipts should be discounted from when they occur. These errors were overlooked in the interest of simplicity but, if desired, all cash flows can be discounted from the exact time they occur. Secondly, all costs (capital and operating) are treated the same way as cash flows.

Uncertainty is an inherent component of agroforestry enterprises (Price and Turner, 1990). This is due to unforeseeable circumstances like extreme weather changes, pests and diseases, fires and price fluctuations. Thus a degree of uncertainty surrounds every estimated value because accurate information on agroforestry production is lacking.

By varying the input or output values at a time, a sensitivity analysis provides additional information on decision-making (Gittinger, 1984). It provides more information whether an alternative is sensitive to risks or not. A sensitivity analysis was carried out using a discount rate of 56 % per annum to evaluate how sensitive the financial viability of the enterprise was due to changes in the discount values. Data were entered in Statistical Package for Social Scientists (SPSS v10) computer programme and analyzed.

Table 1. Comparison of fallow options using enterprise-budgets (Shs. ha^{-1}) for a two year system

	Calliandra calothyrsus			*Tephrosia vogelli*		
	1999/2000	2000/01	Total	1999/2000	2000/01	Total
Capital costs						
Land cost	200,000	0	200,000	200,000	0	200,000
Operating costs						
Seeds	30,000	42,000	72,000	30,000	42,000	72,000
Ploughing	38,000	47,030	85,030	32,000	30,030	62,030
Planting	40,000	45,400	85,400	30,000	45,400	75,400
Weeding	20,000	28,000	48,000	15,000	18,000	33,000
Spraying costs	0	10,000	10,000	0	10,000	10,000
Harvesting	0	32,000	32,000	0	30,000	30,000
Drying	0	12,000	12,000	0	12,000	12,000
Shelling	0	80,000	80,000	0	80,000	80,000
Storage costs	0	6,500	6,500	0	6,500	6,500
Variable cost	328,000	302,930	630,930	307,000	273,930	580,930
Yield/ha (poles)	0	1000	1000	0	600	600
Farm gate price	0	650	650	0	500	500
Gross returns	0	650,000	650,000	0	300,000	300,000
Returns	-328,000	347,070	19,070	-307,000	26,070	-280,930

US$ 1 = Shs. 1980, February 2004

Results

The results of financial analysis were grouped into two: the fallow options available to the farmer and the profitability of the production options.

Comparison of fallow options

Calliandra calothyrsus* and *Tephrosia vogelli

The farmers in the villages of Katuugo, Kyabukoyogo and Kyamalimbi, have two options for fallowing land, namely, *Calliandra calothyrsus* and/or *Tephrosia vogelli*. Table 1 shows a summary of the costs of inputs and outputs associated with each of the two fallow options based on gross margin analysis.

Both fallow options did not generate income in the first year with returns of Shs. – 328, 000 and Shs. – 307,000 ha^{-1} respectively. *Tephisia* fallows had lower variable costs (Shs. 307,000) of establishment than *Calliandra* fallows in the first year (Shs. 328,000). In the second year, farmers obtained more returns from *Calliandra calothyrsus* plots (Shs. 347,070) compared to *Tephrosia* (Shs. 26,070) due to high wood biomass yield that provided poles and fuelwood obtained from *Calliandra*. It was observed that farmers in the study area sold poles or used fuelwood produced by *Calliandra* fallow and, therefore, obtained a higher economic utility and value than *Tephrosia* which resulted into overall economic losses (Shs. – 280,930).

Beans production was costly when fertilizers were used. Fertilizer was the single most costly input accounting for over 72 and 52 % of the FFBP and MIBP production costs, respectively. Consequently, production options requiring less fertilizer such as the ZIBP, CCBP and MIBP were less costly. The highest bean yields were obtained from the fully fertilized plots, but the enterprise margins were reduced by the high fertilizer costs. The fertilizer production systems were more sensitive to a decline in bean yields whereby low yield resulted into an increase in economic losses.

Enterprise budget analysis

The enterprise budget analysis shows that the MIBP enterprise gave the highest returns (Shs. 320,600) during the third season, while the CCBP gave the highest returns (Shs. 180,900) in the fourth season (Table 2). The overall net returns for the four seasons revealed that CCBP gave the highest returns (Shs. 342,970) followed by MIBP (Shs. 332,670), FFBP (Shs. 187,050) and ZIBP (Shs. 20,100). In the first year, the NPVs of all agroforestry options were negative since there were no benefits from the fallow plots. These findings suggest that the ZIBP option was not economically worthwhile as it produced the poorest net returns to scale.

Table 2. Net returns by each enterprises over a four-year period (Shs. ha^{-1})

	Enterprise option			
Production season	**CCBP**	**MIBP**	**FFBP**	**ZIBP**
1999/2000	-328,000	-328,000	36,000	8,200
2000/01	240,070	240,070	62,050	22,000
2001/02	250,000	320,600	104,000	16,500
2002/03	180,900	100,000	-15,000	-26,600
Total	342,970	332,670	187,050	20,100
Mean	85,743	83,168	46,763	5,025

US$ 1 = Shs. 1980, February 2004

Net Present Value (NPV) of production options

The NPVs of the four production enterprises are given in Table 3 (a & b). At 5% discount rate, the CCBP enterprise gave the highest NPV (Shs. 270,132), followed by MIBP (Shs. 264,561). In the first year, the NPVs of all agroforestry options were negative since there were no benefits from the fallow plots. In the third production season, however, both CCBP and MIBP plots registered the highest NPVs (Shs. 217,743; Shs. 276,934) respectively. This result is attributed to the returns obtained from the clearing of *Calliandra* woody biomass. Overall, the *Calliandra* fallow option gave the highest NPV (Shs. 270,132) compared to the other options. The NPVs of the four enterprises increased in the second and third production season. The NPVs of the four enterprises decreased in the fourth season and hence negative returns were realized from the FFBP and ZIBP. These findings suggest that the ZIBP option was not economically worthwhile as it produced the poorest net returns to scale (Shs. 20,132 ha^{-1}). The farmers obtained lower returns from all enterprises at high discount rates of 20%.

Table 3(a). Net Present Values of the enterprises (Shs. ha^{-1}) at a 5% discount rate

	Enterprise option			
Production season	**CCBP**	**MIBP**	**FFBP**	**ZIBP**
1999/2000	-312,387.20	-312,387	34,286.40	7,809.68
2000/01	215,950.00	217,743	56,279.35	19,954.00
2001/02	217,743.49	276,934	89,835.20	14,252.71
2002/03	148,826.43	82,270	-12,340.50	-21,883.83
Total	270,132.72	264,561	168,060.45	20,132.56
IRR	49%	51%	38 x 10^{8}%	93 x 10^{8}%

Table 3(b). Net Present Values of the enterprises (Shs. ha^{-1}) at a 20% discount rate

	Enterprise option			
Production season	**CCBP**	**MIBP**	**FFBP**	**ZIBP**
1999/2000	-273,224.00	-273,224	29,988.00	6,830.61
2000/01	166,608.58	166,609	43,062.70	15.268.00
2001/02	144,750.00	185,627	60,216.00	9,553.53
2002/03	87,193.80	48,200	-7,230.00	-12,821.22
Total	125,328.38	127,212	126,036.70	18,830.94
IRR	49%	51%	45x10^{80}%	10x10^{8}%

US$1 = Ug. Shs. 1980, February 2004

Benefit-Cost Ratio (BCR) of production options

The results of BCR analysis of the four enterprises reduced in order of CCBP (3.35) > MIBP (2.73) > FFBP (1.13) > ZIBP (0.75). This finding suggests that high production costs were incurred in the first year. Only the FFBP enterprise gave a BCR greater than zero (1.12; 1.23; 1.42; 1.00) in all seasons (Table 4). In the second year, the CCBP plots gave returns that were five times (5.2) higher than the cost of production. This far outweighed the other enterprises and the high return can be attributed to the market value of woody poles and firewood of *Calliandra*.

Table 4. Benefit-cost ratio of the four enterprises over a four year period.

	Production season				
Enterprise	**2001/02**	**2002/03**	**2003/04**	**2004/05**	**Mean ratio**
CCBP	0	5.2	4.54	2.34	3.02
MIBP	0	4.9	3.22	1.26	2.35
FFBB	1.13	1.23	1.42	1.00	1.19
ZIBP	0	1.42	1.08	0.62	0.78

Sensitivity analysis

All production alternatives show significant changes in the returns with respect to changing discount rates. The CCBP enterprise was the most sensitive to change of discount rate, with a 53% decline in NPV (Shs. 270,132 to Shs. 125,532). All enterprises were sensitive to change in the discount rate from 5 to 20%, however, ZIBP experienced insignificant change (0.6%). There was 32.65 % average change in discounted net returns to investment (Table 5).

Table 5. Effect of varying discount rate from 5 % to 20% on NPVs (Shs. ha^{-1})

	Enterprise option			
NPV	**CCBP**	**MIBP**	**FFBP**	**ZIBP**
NPV 5%	270,132.72	264,561	168,060.45	201,132.56
NPV 20%	125,532.38	127,212	126,036.70	18,830.94
Total change	144,804 (53%))	-137,349 (52%)	-42,025 (25%)	-1,302 (0.6%)

Discussion

Comparison of fallow options

This study has highlighted that there are benefits in using the *Calliandra calothyrsus* fallow option. As a result of the usefulness of *Calliandra* wood, the farmers indicated higher preference for it than *Tephrosia vogelli*. Consequently, for the bean yields to break-even or to cover all the variable production costs incurred by incorporating *Tephrosia*, the total production of bean should be much higher than that of the *Calliandra* plot. This is because there is less economic benefit from incorporating *Tephrosia* than the bean yields.

For investment in improved *Calliandra* fallow with coppicing nature, the farmers expect a certain series of income every rotation in a given rate of return as a perpetual periodic annuity. This finding is consistent with reports by Price (1993) and Nyirenda *et. al*. 2001 that in agroforestry related investments, the intermediate returns can be reinvested at the same interest rate used in discounting and hence earn more profits.

Our study shows that that the returns to investment in zero input bean production are not economically viable since they result in a BCR of less than one. However, the other options are economically attractive. The *Calliandra* fallow option compared favorably with the full fertilized bean production option. It provided the highest returns to investment and had the lowest production costs. Contrary to the findings reported by Gittinger (1982), our findings suggest that farmers can increase their beans production and improve their welfare by diversifying their investment to include nitrogen fixing tree and annual agricultural crop coupled with reduced application of commercial fertilizers.

The Uganda government is implementing the Plan for Modernization of Agriculture (PMA), a framework for eradicating poverty through profitable, competitive, sustainable and dynamic agro-industrial sector. The mission of PMA is to transform subsistence agriculture to commercial agriculture and improve the welfare of poor subsistence farmers through the use of external inputs such as seeds, fertilizers, implements and chemicals in the agricultural sector and increase demand for processing, marketing, packaging and transportation of increased farm produce (MAAIF, 2000). The increased production of beans by intercropping with *Calliandra* increases productivity per unit area of land. The adoption of such improved fallow agroforestry technologies would contribute to the achievement of the goal of PMA.

Franzel *et. al*., (2002) reported that farmers with less landholdings have appreciated it because of its ability to give a wide range of products within a short time period. Okorio and Kasolo (1996) noted that farm size is used as an indicator of wealth and large scale farmers are likely to adopt an agroforestry technology faster than small scale farmers. However, in situations where *Calliandra calothyrsus is* integrated into the farming systems, it requires intensive management and does better on smaller than larger farms.

However, most technologies that have demonstrated positive agronomic results have not produced good financial results. Financial performance of specific technologies depends on the financial scenario of the community in which it is being practiced. In Uganda, technologies that target the small holder farming community must contend with resource constraints that betroth the group such as low incomes (MAAIF, 2000; Oluka *et al*., 2000). Therefore, there is a need for agroforestry production techniques that are capable of sustaining soil productivity and are affordable to the majority of poor small holder farmers in Nakasongola district and similar agro-ecological zones.

Financial analysis of bean enterprises

Production of beans is an economic activity that follows basic production economics where the farmers objective is to minimise costs and maximise revenue (Upton, 1987). However, land which according to Adesina *et. al*. (2000) is the most important factor of production in beans enterprise was not priced and excluded in the analysis because it was assumed to have zero value since no defined land market existed in the study area.

In the financial farm investment analysis many benefits of trees/shrubs are usually not included because they are difficult to quantify and express in monetary terms. In reality, however, cash impact is the only yardstick farmers use to judge agroforestry investments. This observation is supported by the findings of Upton (1987). Swinkels *et. al*. (1994) linked this revelation to the farmer's motive to maximizing profits using the scarce factors of production available.

There were several transfer payments in form of subsidized inputs and remittances from non-farm activities which were included in the financial analysis. Lack of records regarding taxes, subsidies and government levies made the financial analysis difficult. According to Raussen (1998), estimating the financial benefits of improved fallow options for the farmers is complicated by the different rotation period for the bean crop and *calliandra* tree with a longer maturity cycle. Moreover, many benefits of trees are often not included because they are difficult to quantify and are not expressed in cash terms and yet cash impact, is the only yardstick a farmer uses to judge a profitable investment (Buresh and Tian, 1997).

Indirect benefits of improved fallows to agricultural production, are often neglected for instance, the shade effect of *callinadra* is not monetized as output of the improved fallow enterprise (Paterson *et al.,* 1996). Since shade did not produce direct financial benefits, it was left out of the financial analysis of this study. *Calliandra calothyrsus* is a multipurpose tree that is suitable for a wide range of ecological zones and can give a variety of services and products in agroforestry systems which have both economic and ecological values.

Enterprise budget analysis

The results revealed that in the first year, fallow plots (CCBP and MIBP) had negative net returns (Shs. 328,000 and 280,930) respectively and produced the highest returns in the second year (Shs. 1,632,108). In the second year, fallow plots produced wood biomass which was harvested for poles and fuel wood. According to Raussen (1998), *Calliandra calothyrsus* is a fast growing species, has high coppicing ability, regenerates well when lopped and have high calorific values ranging from 4500 to 4750 K calories per kg with the ash content of 1.8 % and charcoal yield of 35 % with heat value of 7200 - 7580 KJ/kg. In south western Uganda, improved fallows of *Calliandra* produce 27,26, and 24 ton per hectare of firewood in two years (Siriri *et al*., 2000). An average hedge of *Calliandra* spaced at 50 cm produces 6 kg of firewood per meter per year (National Academy of Science, 1980).

Net Present Value (NPV)

The *Calliandra* fallow had the highest NPV compared to the other options while FFBP enterprise gave lower NPVs due to the high costs of fertiliser inputs. In order to deal with inflation affecting current and future costs and benefits of agroforestry enterprises, we assumed that both current input and output prices will retain the same relation. Based on this, we found that in the last season, the option gave a negative NPV following a general decline in beans yields county-wide. This trend contradicts a report by Jama *et al*. (1997) that bean yield increases in the second season after biomass incorporation in agroforestry systems. The difference can be attributed to general poor yields resulting from too much rainfall during the 2000/01 growing season whereby nitrogen was leached and consequently low yields obtained. The agroforestry trees help to minimize the effects of the leakage, example, according to Siriri *et. al*., (2000) one kilogram of *Calliandra* leaves contains about 30 grams nitrogen, 10 grams phosphorus and 2 grams potassium. Among marc-nutrients nitrogen is limiting for crop production. Seriri and Bekunda (2001), Raussen

(1998) and Mugendi *et. al*. (1999) reported that like nitrogen, phosphorus deficiency is a major problem in East Africa including the study area, where soils are strongly to moderately acidic in nature.

Raussen (1998) reported that *Calliandra* and *Tephrosia* provided a variety of indirect products and services such as fodder, food, firewood, bee forage, stakes and soil fertility improvement, soil erosion prevention and shade provision. Both species have a positive effect on the environment and contribute to the maintenance of soil fertility. They also provide many other products such as forage, fruits, cordage, tanning flowers, medicines, dyes, and firewood.

Benefit-Cost Ratio (BCR)

The study has revealed that while the NPV shows the future worth of the four enterprises, in practice, farmers' decision to invest is not restricted to the profit-maximization objective alone. The cost of production, relative to the returns to investment, is also of interest to farmers. The *calliandra* fallow had a high BCR (3.02) compared to zero input option (0.78). Farmers need to know that the potential benefits from C*alliandra* fallow option are higher than the production costs in order to grow the species together with agricultural crops.

The costs and benefits of the FFBP enterprise did not vary considerably across the seasons this due to the stable market condition in the country and government policy to encourage farmers to shift from heavy dependency on agro-chemicals to organic farming. The costs of production remained high throughout due to the high cost of fertilizers. The artificial fertilizers were expensive (Shs. 200 per kg of Urea) and farmers could not afford to buy them. This perhaps explains the farmers' choice of *Calliandra* and *Tephrosia* as agroforestry tree species for soil fertility replenishment.

Our study shows that the crucial element in the analysis of the farmers investment decisions, is the correct choice of the going interest rate. When the discount rate was 5 %, the NPV of incremental benefits from all the four enterprises were higher than when the discount rate increased to 20 %. At a discount rate of 20 % it would be economical to invest in another land-based project such as fish farming and vanilla growing which are currently preferred in the study area and they seem to yield positive NPV. Different scholars (Denning, 2001; Gittinger, 1982; Swinkels *et. al*., 1994) recommended the shadow price to be used in valuation of improved fallow agroforestry technology because the market price is thought to be a poor estimate of the economic value. Uganda has competitive markets without artificial restrictions. This suggests that market prices are the best estimates of the value of agricultural products such as beans and agroforestry products such as fruits. The proximate risks such as pests and diseases experienced by small-scale farmers were sufficient to overshadow the differences in the household managerial ability. The risk of production and reliance on the market often forces poorer producers to adopt subsistence-oriented strategies. The PMA is intended to overcome this problem.

Conclusions and recommendation

1. The improved fallow agroforestry system is economically viable.
2. There are benefits in using the *Callindra calothyrsus* fallow option such as revenues obtained from the sale of poles and fuelwood in addition to soil fertility gains obtained from the fallows.
3. The *Calliandra calothyrsus* fallow option compared favourably with the full-fertilised beans production option by providing the highest returns on investment and the lowest production costs.
4. Farmers can increase their beans production while reducing their investment in other crop production through reduction in fertiliser inputs.
5. The artificial fertilizers are expensive and farmers cannot afford to buy them.

Therefore, it recommendaded that institutional arrangements are put in place to encrouge the adoption of *Calliandra and Tephrosia* as agroforestry tree species in Nakasongola district.

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References

Adesina, A.A., Mbila, D., Nkamleu, G.B. and Endamana, D., 2000. Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of Southwest Cameroon. *Agriculture, Ecosystems and Environment* 80 (3): 255-265.

Buresh, R.J., and Tian, G., 1997. Improvement by trees in sub-Saharan Africa. *Agroforestry Systems* 39 (1/3): 51-56.

Byerless, D.L., Harrington, L., and Winkleman D.L., 1982 Farming System Research: Issues in Research Strategy and Technology Design. *American Journal of Agricultural Economics* 64: 897-904.

Denning, G.L., 2001. Realising the potential of Agroforestry: integrating research and development to achieve greater impact. *Development in Practice* 11(4):124–158. Carfax Publishing.

Franzel, S., Phiri, D., and Kwesiga, F., 2002. Assessing the Adoption potential of Improved Fallows in Eastern Zambia. *AFRENA Report* No. 124.

Gittinger, J., 1982. Economic Analysis of Agricultural Projects. IBRD World Bank, Washington, U.S.A.

Jama, B., Swikels, R.A., and Buresh, R.A., 1997. Agronomic and economic evaluation of organic and inorganic sources of Phosphorus in Western Kenya. *Agronomy Journal* 89: 597 – 604.

MAAIF (Ministry of Agriculture, Animal Industries and Fisheries). 2001. National Agricultural Advisory Services Programme (NAADS); Master Document of the NAADS Task Force and Joint Donor Groups, MAAIF, Entebbe. Uganda. Pp. 32 – 39.

Mugendi, D.N., Nair, P.K.R., Mugwe, J.N., O'Neill, M.K., Woomer, P.L., 1999. Alley cropping of maize with *Calliandra* and *Leucana* in the sub-humid highlands of Kenya. Part 1 . Soil fertility changes and maize yield. *Agroforestry Systems* 46 (1): 39-50.

MUIENR (Makerere University Institute of Environment and Natural Resources). 2000. *National Biodiversity Data Bank Report 2000*. Makerere University. Kampala, Uganda.

National Academy of Sciences., 1980. Firewood crops, shrubs and tree species for energy production. NAS. Washington D.C.

NEMA (National Environment Management Authority)., 2001. The State of the Environment Report Uganda. Kampala, Uganda.

Nyirenda, M., Kanyama-Phiri, G., Bohringer, A., and Haule, C., 2001. Economic performance of improved fallow agroforestry technology for smallholder maize production in Central Malawi. *African Crop Science Conference Proceedings*, Vol. 5. Pp. 638 – 687. African Crop Science Society, Kampala Uganda.

Okorio J. and Kasolo, W., 1996. Agroforestry in Uganda: Proceedings of National Workshop on Agroforestry in Uganda.

Mukono District Farm Institute. *ICRAF*, Kampala, Uganda.

Oluka, A., Esegu, F., Kaudia, A., 2000. Agroforestry Handbook for the Banana-Coffee Zone of Uganda, *Technical Hand Book No. 21*. The Regional Land Management Unit. RELMA/SIDA, ICRAF.

Paterson, R.T., Kiruiro, E. and Arimi, H.K., 1996. The use of *Calliandra calothyrsus* for milk production . *National Agroforestry Research Project*, Embu. Kenya.

Pearce, D.W. and Turner, R.K. 1990. Economics of Natural Resources and the Environment. Lawon Harvester Wheatseaf.

Price, C., 1993. Time, Discounting and Value. Blackwell Publishers. Oxford, UK.

Raussen, T., 1998. Useful trees for Farming: *Calliandra calothyrsus*. AFRENA-Project Uganda. *Technical Bulletin* No 1.

Siriri, D., and Bekunda, M.A., 2001. Soil fertility Management in Uganda: The potential of Agroforestry. AFRENA, Kabale, Uganda.

Siriri,D., Raussen, T. and Poncelet, P., 2000. The development potential of Agroforestry technologies in Southwestern Uganda. *Agroforestry Trends* 2000.

Swinkels, R., Franzel, S and Shepherd, K 1994. Economic analysis of on-farm improved fallows in western Kenya. *ICRAF Training Note*. ICRAF, Nairobi, Kenya.

UBOS (Uganda Bureau of Statistics). 2002. Provisional Population Census Results. Entebbe, Uganda.

UHDR (Uganda Human Development Report). 2000. Ministry of Finance, Economic Planning (MFEP). *Uganda Human Development Report*. Kampala, Uganda.

Upton, M. 1987. African farm management. Department of Agricultural *Economics and Management , University of Reading.* Cambridge University Press.