

Accepted for publication in: "Journal of Sustainable Agriculture"

Date of acceptance by journal: 09 May 2006

Formatted: Normal, Left

Formatted: Font: Arial

**User acceptability of sustainable soil fertility technologies:
Lessons from farmers' knowledge, attitude and practice in southern Africa**

Ajayi, O. C.

Agricultural Economist
SADC-ICRAF Agroforestry Programme
c/o Chitedze Agricultural Research Station
P.O. Box 30798, Lilongwe 03
MALAWI

Tel: +265-1-707329

Fax: +265-1-707323

Email: ajayi@gmx.net

User acceptability of sustainable soil fertility technologies:
Lessons from farmers' knowledge, attitude and practice in southern Africa

Abstract

Low soil fertility is one of the greatest biophysical constraints to agricultural production in sub-saharan Africa. "Improved fallow", an agroforestry-based soil fertility replenishment technology was developed in response to the depletion of soil fertility and increasing difficulty of small scale farmers to afford mineral fertilizers. The biophysical performance of the technology to improve soil fertility and increase crop yield has been well demonstrated and efforts are being made to enhance the adoption its adoption by farmers. But there is relatively little information and systematic feedback regarding farmers' perception and knowledge of the technology. Using data collected from a stratified sample of 302 farmers in Zambia, this study analyzed farmers' knowledge, attitudes and perceptions of soil fertility and food security problems, highlighting implications for user acceptability and the development of sustainable soil fertility management technologies.

Results show that farmers have good understanding of soil fertility issues, its linkage to food security and household welfare indicators. They appreciate improved fallow because it responds to the critical problems of low soil fertility and provides additional benefits to the household. However there are some challenges to the widespread uptake of the technology including land constraints, property rights availability of seeds, knowledge-intensive nature of the technology. Farmer acceptability and improved adoption of the technology will be influenced by the extent to which efforts are taken to meet these challenges. Farmers' response on knowledge, attitude and perception provides valuable inputs for further development and modification of the technology. Beyond technology development, an understanding of farmers' preference and other contextual issues within which the technology is expected to be adopted will enable researchers to develop appropriate sustainable technologies and enhance user acceptability of the same. The study shows that technical characteristics are important but not exclusive conditions for farmers' acceptability and adoption of good agricultural technologies by farmers.

Keywords: Agroforestry, Farmer perceptions, Improved fallow, Participatory research, Sustainable agriculture, Zambia

1.0 Introduction

For several generations, farm communities in sub-saharan Africa have been leaving their farm land on a long natural fallow system as a means of replenishing the fertility of their soils. Over several years, increases in human population and a decrease in per capita land availability led to a breakdown of the system, shortening of fallow periods and degradation of soil fertility. For most crops, little or no fertilizer is used because it is not available or not affordable for most small scale farmers who constitute the majority of the farming population. With an estimated annual soil nutrient depletion rate of 22 kg/ha for nitrogen, 2.5 kg/ha for phosphorus, and 15 kg/ha for potassium in Africa (Smaling et al., 1997), poor soil fertility has emerged as one of the greatest biophysical constraints to increasing agricultural productivity in the continent (Bekunda et al., 1997; Sanchez, 1999). As a result, the need for improvement in soil fertility management has become a very important issue in the development policy agenda for the continent (NEPAD, 2003; Scoones and Toulmin, 1999).

“Improved fallow technology” also known as “fertilizer tree fallow” is a sustainable soil fertility replenishment technology developed in response to the depletion of soil fertility and increasing difficulty of small scale farmers to afford mineral fertilizers. Based on agroforestry principles, the technology involves planting fast-growing, nitrogen-fixing leguminous trees that produce decomposable biomass (Kwesiga and Coe, 1994). In addition to increasing the availability of nitrogen through atmospheric fixation of N₂, fertilizer trees also increase soil organic matter and improve soil physical conditions (Kwesiga et al., 1999). Given the profitability of fertilizer tree fallows (Franzel et al., 2002) and the impact of the technology on households and the

environment (Ajayi et al., 2004; Kwesiga et al., 2005), efforts are being made to scale up the adoption of the technology and enhance its acceptability among many more potential farmers who could benefit from the technology.

However, acceptability and adoption of a new technology involves not only its biophysical and economic profitability, but also requires adequate knowledge of a number of factors including how users perceive the underlying problem, their attitude, beliefs and practices related to the intervening solutions offered to them by the technological innovation (Flett et al., 2004; Franzel et al., 2001; Schroth and Sinclair, 2003). It was demonstrated in several studies that the decision of farming communities to adopt new agricultural technologies is strongly influenced by users' knowledge and perceived economic returns between existing and the new innovation (Adesina and Baidu-Forson, 1995; Adesina and Zinnah, 1993; McDonald and Glynn, 1994). This is particularly true for sustainable natural resource management technologies where cost of adoption is incurred upfront, separated from benefits by a time interval that is generally longer than that of annual crop technologies. While economic considerations and short-term profitability of agroforestry technology generally increase the probability of adopting a given technology (Ayuk, 1997; Haggblade et al., 2004), economic models alone do not fully explain farmers' behavior of technology adoption. According to Flett et al. (2004), this is because adoption involves key attitudinal components: perceived usefulness (i.e. the extent to which a person believes that using a particular technology will enhance their job) and perceived ease of use (i.e. user's perception of the ease or difficulty of learning and using a given technology).

The biophysical performance of fertilizer tree fallows to improve soil fertility and increase crop yield has been well demonstrated (Chirwa et al., 2003; Kwesiga and Coe, 1994; Mafongoya et al., 2003), but information and systematic feedback regarding farmers' perception and knowledge of the technology and soil fertility management in southern Africa is comparatively scanty. The overall objective of this study is to contribute to the enhancement of adoption of sustainable soil fertility management technologies through systematic feedback on user assessment and acceptability of fertilizer trees. The specific aims are to (i) analyze farmers' knowledge, attitudes and perceptions on soil fertility, food security problems and fertilizer tree fallows (ii) identify opportunities and constraints to the adoption of fertilizer tree fallows emanating from existing knowledge and perceptions of farmers and, (iii) highlight implications for technological development and dissemination of information regarding fertilizer tree fallows.

2.0 Materials and methods

2.1 Description of study area and evolution of soil fertility management policies

The study took place in eastern Zambia, noted for hosting early field experimentations in the development of fertilizer tree fallows and where considerable farmers have adopted the technology. Eastern Zambia is located between latitude 10° – 15° S and longitude 30° - 33° E with an altitude ranging from 900 to 1200 m above the sea level. The average annual rainfall is 1000mm and most of the rains occur between December and March. The vegetation is typical of the eastern and central plateau miombo woodland dominated by tree species like *Brychystegia*, *Julbernardia*, and

Isoberlina. The agricultural economy is dominated by mainly by maize, groundnut, cotton and vegetables all of which are cultivated in small fields that are less than 2 ha. Some localities also engage in agro pastoral farming. The major ethnic groups in the area are *Ngonis* and the *Chewas*.

National policies on soil fertility management in Zambia have evolved greatly in the past four decades. National policies to address decline in soil fertility have focused primarily on use of subsidized mineral fertilizers. The government of Zambia introduced fertilizer subsidies in 1971-72 season and almost all the subsidized inputs were directed towards maize (a politically strategic crop in the country). Initially, subsidies were 30 percent of landed cost of fertilizers, but it averaged 60 percent by 1982 (Howard and Mungoma, 1996). The removal of subsidies and collapse of the para-state marketing system in the late 1980s and early 1990s had dramatic negative effects on fertilizer use. The ratio between nitrogen and maize prices increased four-fold, and as a result fertilizer use in Zambia declined by 70%. Fertilizer tree fallow is meant to ameliorate this constraint.

2.2 Sampling technique and data collection

Five agricultural districts were chosen for the study. Four of them (Chipata North, Chipata South, Katete and Chadiza) were selected because they are the key pilot locations where testing and dissemination of the technology has taken place. The fifth district (Petauke) had received extension messages on agroforestry technologies through the Soil Conservation and Fertility Enhancement program (SCAFE). In each district, a sampling frame was drawn up based on a list of farmers who planted fertilizer trees as compiled by

a previous study in the study area. The list was supplemented with information from the database of Zambia Integrated Agroforestry Project (ZIAP) and the Land Management and Conservation Farming (LMCF) department of the Ministry of Agriculture and Cooperatives. The sampling frame for each district was stratified by gender from which a random sub-sample size of 202 agroforestry farmers was selected. The number of farmers selected in each agricultural district varies in proportion of the relative level of farmers who planted fertilizer tree fallows in the district. In addition, 100 farmers who do not plant fertilizer tree fallow (non adopters) but who reside in the same districts were randomly selected as “control”. Thus the total sample size of 302 farmers interviewed in the study is made up of two types of farmers: those who planted fertilizer tree fallows (“agroforestry farmers”) and farmers who do not (“non agroforestry farmers”). The distribution of the farmers is presented in Table 1. Interviews were conducted with farmers using a ten-page structured questionnaire to obtain information on their knowledge, attitude and perceptions of various issues including agricultural production constraints, soil fertility and food security, technology adoption, preferences and impacts of various soil fertility management methods and, preferences of agro-forestry species.

Table 1: Number and distribution of farmers selected for the study

Descriptive statistics and t-tests were carried out using Statistical Analysis Systems (SAS) software Version 9.1 to identify systematic trends in farmers’ responses and highlight differences (where they exist) in the perceptions of farmers based on gender and type of farmer.

3.0 Results and discussion

3.1 Agricultural production and constraints

3.1.1 Crop production: Maize and groundnut are the most popular crops in the study area and are grown by all the households interviewed. Sunflower is grown by about half of the farmers (48%), a third of the farmers (31%) grow cotton and others grow beans (29%) and sweet potato (12%). The mix of crops planted by the farmers reflects a desire to satisfy both household food security and cash requirements and also a coping mechanism to mitigate risk of crop failure. Although maize is regarded as “the crop” and will most likely retain this status in the immediate future, there are indications that other crops that are becoming important in the cropping systems. In particular, cotton has become increasingly popular in recent years due to the out-grower scheme embarked by cotton companies including Dunavant, Clark Cotton and recently Zambia-Mulungushi Textile Company. Given that almost all the previous biophysical trials on fertilizer tree fallows have been carried out almost exclusively on maize, there is need to broaden this assessment by evaluating the performance of the technology on “new” but important crops particularly cotton, paprika and other high value crops.

3.1.2 Major agricultural constraints: The major agricultural constraints mentioned by farmers are presented in Table 2. The constraints follow similar trend for all different types of farmers interviewed, i.e. male and female farmers and, those who planted fertilizer tree fallows and otherwise. The constraints that were most frequently mentioned were related to fertilizer and soil fertility issues. These include poor soil

fertility, lack of cash to buy mineral fertilizers or non availability of fertilizers in rural areas at the right time. The next group of constraints is weather-related i.e., soil erosion, inadequate amount and irregular pattern of rainfall. This constraint is important to farmers because the region has only one single season of rainfall (duration of about five months only) annually within which crop production activities take place. Given that agriculture is predominantly rain fed (irrigation occurs in exceptional cases only), the amount and distribution of rainfall becomes critical. A surprise noted in the table is that only a modest proportion of farmers mentioned availability of seeds as a constraint. This is most probably because farmers generally recycle seeds harvested in their fields in preceding years.

Table 2: Major agricultural constraints mentioned by farmers

3.2 Soil fertility problems and methods

The potential to adopt soil improvement technologies is higher where farmers are aware and concerned about the fertility of their soils. One out of every two respondents perceive that their soils are poor or very poor, irrespective of gender (Table 3) indicating that fertilizer tree fallows responds to real problems faced by farmers. This is important because if farmers do not perceive that there is soil fertility problem, financial profitability may be insufficient to motivate adoption of new technologies (Haggblade et al., 2004).

Table 3: Farmers' assessment of status of fertility of soils in Zambia

Farmers exhibited good understanding of soil fertility issues based on their farm experience over several years. They assess the fertility status of soils based on vegetative growth and crop yield (70%), proxies such as presence of *Striga spp* and noxious weeds (15%), color and physical texture of soil (12%) and yellowing of leaves of maize (12%). Farmers generally regard dark colored soils as fertile while they assume that bright colored (yellow) maize crop is an indication of poor soil.

3.3 Farmers' use and assessment of soil fertility improvement methods

3.3.1 Use of soil fertility replenishment methods: Only one in ten farmers (11%) mentioned that they use mineral fertilizers attributing the low figure to high cost and non availability of the inputs in their village at the right time. In addition to mineral fertilizers and fertilizer tree fallows, several options including crop rotation (67%), animal manure (28%) and, natural fallow (19%) are used to address the deterioration of soil fertility. The reasons cited for using multiple options are “to fully restore soil fertility” (44%), “each method has unique “characteristics (20%), “to reduce expenses associated with mineral fertilizers” (12%) or a combination of these reasons.

3.3.2 Farmers' perception of agroforestry-based soil fertility technology: The key advantages of improved fallow technology over mineral fertilizers cited by farmers are as follows: they are “cheaper” and does not require direct cash expenses associated with

mineral fertilizers; their fertility effects last for more than one season; they serve multiple purposes (fodder for livestock and fuelwood) in addition to improving soil fertility; they improve biophysical functions (e.g. suppression of noxious weeds and “softening” of soils which facilitates easier weeding operation) and opportunity for obtaining cash income from sale of agroforestry seeds. In addition, farmers perceive that improved fallow “does not destroy the soil”, it is readily available in the villages, and because it produces maize crops that gives better taste. Farmers’ interests to practice fertilizer tree fallows most probably go beyond soil replenishment issue to include the above mentioned perceived advantages.

Table 4: Perceived advantages and challenges of agroforestry compared with mineral fertilizers

Nevertheless, farmers itemized some disadvantages of fertilizer tree fallows (Table 4). Problems of bush fires and animal browsing have been recognized by technology developers, forcing researchers to discontinue the use of pigeon pea (*Cajanus cajan*) because livestock browsed it extensively (Franzel et al., 2002). In collaboration with the farming communities, traditional authorities have enacted by-laws to reduce the constraints of fires and livestock browsing (Ajayi and Kwesiga, 2003). Field studies (Ajayi et al., 2004; Franzel et al., 2002) show that the perception of “labor constraints” do not necessarily imply higher quantity of labor is required for fertilizer tree fallows, but the introduction of the technology into the farming system obliges farmers to provide *additional* labor inputs for nursery and planting of trees within a short period, over and

above the labor that they normally require in conventional crop fields. Some farmers consider the two years they have to wait before getting benefits from fertilizer tree fallows as “too long”, a perception that is not unexpected in countries where inflation and discount rate is quite high. Some farmers mentioned that agroforestry seedlings sometimes dry up shortly after transplanting. It was curious to note that insufficient seed was mentioned by only a small proportion of farmers and this is probably because farmers usually re-cycle seeds from their own fields and most of the plant species used in improved fallow systems in the study area are prolific seed producers. The exception is *Gliricidia sepium* which produces fewer seeds, takes relatively longer time to produce them, and sometimes the few seeds may be lost due to shattering. Recently, private organizations and individuals have established *Gliricidia* seed orchards for sale to farmers which is expected to reduce seed availability constraints for this species in the future.

The level of appreciation of the benefits and challenges of fertilizer tree fallows is much higher for farmers who are already practicing the technology. A greater proportion of these farmers mentioned much more advantages and constraints associated with the technology while non-agroforestry farmers generally mention that they don't know. Extension messages on fertilizer tree fallows should be packaged to help non agroforestry farmers to appreciate the advantages while taking measures to train them on ways to reduce the constraints highlighted by agroforestry farmers.

3.3.3 Farmers' perception of mineral fertilizers: Irrespective of gender and ownership of agroforestry field, almost all the farmers interviewed (93%) like and highly

appreciate mineral fertilizers because “it produces bumper harvest” within a relatively short period. They also like the input because it is effective and requires lower labor inputs to work with it.

Table 5: Advantages and constraints associated with mineral fertilizers

The key complaints of farmers regarding mineral fertilizers is that they “spoil the soil”, they need to be applied repeatedly each farming season; they are expensive and must to be procured on cash or credit (neither of which is readily available to farmers). A baseline survey of the study area (Peterson 1999) reports that in addition to lack of cash, farmers’ perceptions that fertilizer depletes the soil are constraints limiting fertilizer use in eastern Zambia. Similar results were reported in a study conducted in western Kenya (Place et al., 2003). This perception is probably linked to acidification and lowering of soil PH from repeated application of the input.

3.4 Farmers’ indicators of adoption

In general, quantification of adoption rates of natural resource management technologies is elusive because partial and incremental adoption by farmers makes precise measurement difficult. For agroforestry technology, a precise definition of “adoption” is sometimes a challenge because agroforestry adoption decisions are more complicated than those for annual crops and modern agricultural development packages based on chemical inputs (Mercer 2004; Scherr and Müller 1991) due to the multi-components and the multi-years through which testing, modification and “adoption” of

agroforestry takes place. Some studies (Adesina et al., 2000; Franzel et al., 2002) have delineated between farmers who are in ‘testing’ or ‘experimenting’ phase from those in ‘adoption’ phase of agroforestry. According to Ajayi et al (2003), adoption of agroforestry could be regarded as a continuum in which individual farmers are conceptualized to occupy positions in the adoption continuum depending on the extent to which they have taken up various components of the technology. In this present study, we asked questions from farmers to gain insights into their perspectives of “adoption” of agroforestry¹. Their response is similar to what has been discussed in the literature of agroforestry adoption. They indicate that that among individuals who plant improved fallow tree species, some are more “adopters” than the others.

Table 6: Farmers criteria for assessing adoption of agroforestry

As presented in Table 6, farmers assess agroforestry adoption through the following indicators: good management of agroforestry fields (timely weeding and pruning of trees), density and mixture of different trees species planted, continuous use of the technology for several years, area of field devoted to agroforestry species, regular participation in agroforestry-related meetings and willingness to train fellow farmers on agroforestry issue on voluntary basis. Another important indicator is the extent of the visible change that has occurred to an individual’s household as a result of using the technology i.e., whether an individual has successfully transformed from a maize-deficit

¹ We asked this question from respondents using an analogy as follows: “If all the farmers in your village were arranged in a single line and you were asked to categorize them into “agroforestry adopters” and “non adopters”, what characteristics will you consider before you assign individuals into either of the groups”?

(food insecure) to maize surplus (food secure) household. Land area cultivated to agroforestry, timely weeding, rendering voluntary services to promote agroforestry and the length of years of uninterrupted practice of the technology are indications of the priority that a farmer assigns to agroforestry among the various farm activities that compete for his/her resources. All of farmers' indicators of adoption can be summarized into two groups: (i) demonstrated commitment and (ii) visible impact of the technology on food production. To enhance scaling up of the technology, farmers who performed well in these two groups of indicators should be identified to serve as farmer trainers² for farmer-to-farmer diffusion of the technology. Such farmers would most likely serve as models of an agroforestry farmer and would be expected to provide convincing messages to fellow farmers through their commitment to agroforestry and demonstrated impact of the technology on their households.

3.5 Impact of fertilizer tree fallows

The most frequently mentioned impact of fertilizer tree fallows that agroforestry farmers mentioned is that their crop production has increased due to the improved fertility of their soils (Table 7). The increase in crop production from agroforestry fields is corroborated by the information obtained from farmers on the status of food security. Taking farmers' own definition of food security (i.e. "having enough food or maize for every members of the household"), we asked interviewees to provide quantitative response to food security indicators such as number of month per year they had enough

² These are farmers (generally considered to be more knowledgeable in agroforestry) who have been selected to train other farmers in the villages on the implementation of the operations on agroforestry technologies.

food to feed their family members. A t-test of these indicators show that agroforestry farmers are significantly more food secure than non agroforestry farmers. On average, farmers who planted fertilizer tree fallows have sufficient food for all members of their households for a period of 9.82 months per year, significantly higher than 9.20 months per year for farmers who do not practice the technology (Pr=0.0885) even though agroforestry households have larger family members (7.1 members compared with 5.9 for non-agroforestry farmers). Since only one in ten farmers in the study area used fertilizer, the increased crop production in agroforestry fallow fields contributed to higher food availability.

Table 7: Impact of fertilizer tree fallows on households in Zambia

Some interview respondents also mentioned improved availability of fuelwood, opportunities of earning extra cash income from the sale of agroforestry seeds to projects and, use of agroforestry species (*Tephrosia spp*) as bio-pesticides to control ticks from their livestock. About a third of the farmers established fertilizer tree fallows more recently and so could not provide precise information on the impacts of the technology as it takes about 2 years before farmers get substantial benefits from the fallows. Other impacts mentioned by interview respondents include improved ability to pay children's school fees, freedom from debts and begging for money and increased sale of farm produce. The impact of fertilizer tree fallows on farmers has been described in details elsewhere (Ajayi et al., 2004).

3.6 Opportunities and constraints to enhance adoption of fertilizer tree fallows

3.6.1 Constraints to planting fertilizer tree fallows: Results of the interview show that among farmers who planted fertilizer tree fallows, about half of them (48%) has increased the size of the field grown to the technology beyond the plot size they started with initially. For other farmers, the size of agroforestry plot has remained the same (41%) or decreased (11%) over the years due to labor constraints, inadequate land, lack of seeds (especially for *Gliricidia*), pests and frequent fires. For non adopters, land constraints (inadequate size and insecure tenure), knowledge-intensive nature of the technology, labor constraints and non-availability of seeds were the most frequently cited (Table 8).

Table 8: Reasons for not planting fertilizer tree fallows

Where tenure is insecure, non-land owners and immigrants may be cautious to invest their resources on long term tree establishment if they are not assured of obtaining long term benefits from their investments. The effects of land tenure arrangements on the adoption of natural resource management technologies have been described in details (Otsuka and Place, 2001). Time lag is important for farmers because although agroforestry are profitable over time (positive net present values), their break-even point occurs somewhere between 2 to 3 years, implying that farmers must absorb net losses for a couple of years before receiving profits from adoption of the technologies. This poses a challenge to farmers in low income nations where the cost of capital and discounting factor is high. As part of the continuous modification of the technology, the introduction

of legume species like *Tephrosia candida* which effectively reduce the “waiting period” of fertilizer tree fallows system by 50% (to just one year of fallow) would contribute to making the technology more appropriate for resource-poor farmers. Lack of agroforestry seeds in sufficient quantity and quality, were identified by a quarter of non adopters as the reason for not planting fertilizer trees. A method to provide small quantity of “starter seeds” as loans at initial stages will encourage the adoption of the technology among farmers who are currently not practicing the technology. After tree maturity, the seeds may be recovered (with interest) and given to others farmers, while applying similar recovery measures. In addition, fertilizer tree fallows are management and information intensive and require skills in terms of land allocation and maintenance of the technology. Mechanisms for the introduction of germplasm and technical support for managing tree fallows are important. Beyond technology development therefore, policies regarding land tenure and other issues related to property rights among other appropriate policies are important issues that should be considered in the scaling up of fertilizer tree fallows within communities.

. *3.6.2 Source of information on agroforestry:* Farmers who planted fertilizer tree fallows obtained information regarding the technology through government extension workers (34%), ICRAF project staff (27%) and World Vision agroforestry Project (17%). Others did through individual farmers designated as “farmer trainers” (18%) and direct farmer-to-farmer dissemination of information on the technology (7%). There are opportunities to increase farmer-to-farmer exchange of information on the technology from the current aggregate level of 25% to a higher level. Due to the presence of

government extension workers in almost all the agricultural camps³ in Zambia, there is an opportunity to improve farmers' knowledge on fertilizer tree fallows through this channel than is done presently. This can be achieved by enhancing the technical competence of government extension workers on fertilizer tree fallows and formally institutionalizing agroforestry into the mainstream programs and activities of the ministry of agriculture and natural resources.

3.6.3 Farmer associations and training groups: Overall, three quarters (74%) of all the farmers interviewed belong to one or more farmers' association or training clubs. Although the primary aim of the groups are "to reduce poverty" (37%), increase farmer training (22%), facilitate access to agricultural loan and inputs (19%) and enhance literacy (10%), there is a potential to use the existing groups as entry points for fertilizer tree fallows. Such clubs and cooperative groups provide channels for their members to access information on agroforestry and other agricultural practices. The result of this study shows that membership in farmers' groups is positively correlated with the adoption of fertilizer tree fallows.

3.6.4 Preference for specific fertilizer tree fallows species: Farmers' preference for specific fallows species is based mainly on quantity of biomass produced because farmers are of the opinion that this determines the effectiveness to replenish soil. Total plant biomass is a measure of value and productivity and also a good proxy for carbon sequestration, pollution filtration, or other valued ecosystem services (Tilman et al.,

³ An "agricultural camp" is an lowest agricultural administrative unit made up of 150-200 households and supervised by an Agricultural Extension Agent.

2005). Ease of plant establishment refers to whether a species can be established through direct sowing, a method that eliminates the need for nursery operations and hence reduce labor requirements.

Table 9: Reasons for preferring specific agroforestry species

Farmers also prefer plant species that re-sprouts (“coppices“) after being cut because this eliminates labor that would otherwise be required to re-establish fallows continually. The preference for species that produces large quantity of marketable seeds may be an indication of farmers’ desire for immediate cash income, while they wait for the benefits of improved soil fertility. Farmers also give preference to species that have shorter payback period (most probably to ensure that farmers recover their investment cost at the earliest possible period), less-prone to attack by pests, livestock and fire. Some farmers prefer plant species that pose less constraint for oxen-drawn implements during farm operation operations. The preferences expressed by farmers indicate that while fertilizer tree fallows technology is designed primarily to improve soil fertility which is then expected to raise farmers’ income indirectly through higher crop yield in the longer term, results show that farmers show clear preference for fallow species that *both* provide cash income in the immediate terms in addition to increasing the fertility of their soil in the medium term. This is similar to the findings of a recent study where "cash" or "increased income" was the most frequent response mentioned by farmers as their initial motivation to test soil and water conservation technologies (Haggblade et al., 2004).

4.0 Summary and conclusion

Drawing from their farm experience over several years, farmers exhibited good understanding of soil fertility issues, its linkage to food security and household welfare indicators. They appreciate fertilizer tree fallows technology as a sustainable solution because it responds to the critical problems of low soil fertility and provides additional benefits. However, land constraints, knowledge-intensive nature of the technology, labor constraints, and non-availability of seeds affect the expansion of area grown to fertilizer tree fallows. Beyond technical characteristics, policies regarding land and other issues related to property rights among other appropriate policies are important issues that should be considered in the scaling up of fertilizer tree fallows within communities. There is need to improve the availability of information on the technology. Existing farmers' groups offer potential entry points for fertilizer tree fallows and provide channels for their members to access information on agroforestry and other agricultural practices. Efforts to improve the adoption of fertilizer tree fallows need to take advantage of potential opportunities while making efforts to reduce the constraints that exist in the current level of knowledge, practices and perceptions of farmers with regards to fertilizer tree fallows.

While farmers regard maize as “the crop” and will most likely retain this status in the immediate future, other crops are becoming important in the farming systems. For several years, biophysical trials on fertilizer tree fallows have been carried out almost exclusively on maize. There is the need to assess the performance of fertilizer tree fallows on emerging important crops like cotton, paprika, vegetables and other high value crops. This will enhance its adoption by widen its appeal to different typologies of

farmers. The high interest shown by farmers in “biomass transfer” (using biomass from *Gliricidia sepium* to fertilize soils) to produce high value crops lends credence to this.

While soil fertility is still a major constraint to farmers, farmers indicate prefer agroforestry soil management options that satisfy multiple goals: reduction on the cost of fertilizer and provision of cash income to their households in the short term in addition to improving soil fertility in the longer term. An understanding of this preference will enable researchers generate appropriate sustainable technologies and enhance user acceptability of the same. The study shows that technical characteristics are important but not exclusive conditions for farmers’ acceptability and adoption of good agricultural technologies by farmers.

Acknowledgement: The author thanks Webby Kanjipite, Marks Mwale and Fred Musonda of the Land Management and Conservation Farming (LMCF) unit for the field assistance rendered during data collection, the World Vision for availing us the database for the sampling frame and, Rockefeller Foundation and Canadian International Development Agency (CIDA) for providing financial assistance for the study, and anonymous reviewers of the journal for their helpful insights. The usual disclaimer applies.

5.0 References

- Adesina, A.A. and J. Baidu-Forson (1995). Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, west Africa. *Agricultural Economics* 13:1-9. [doi:10.1016/0169-5150\(95\)01142-8](https://doi.org/10.1016/0169-5150(95)01142-8)
- Adesina, A.A. and M. M. Zinnah (1993). Technology characteristics, farmers' perceptions and adoption decisions: a Tobit model application in Sierra Leone. *Agricultural Economics* 9 (4): 297-311. [doi:10.1016/0169-5150\(93\)90019-9](https://doi.org/10.1016/0169-5150(93)90019-9)
- Ajayi, O.C., Place F. and F. Kwesiga, P.L Mafongoya. 2004. *Impacts of Natural Resource Management Technologies on Small-scale Farmers: Case of Fertilizer Tree Fallows in Zambia*. Presented at the CGIAR's Standing Panel on Impact Assessment (SPIA) Workshop on Impact Assessment of Natural Resource Management Research, June 18-19, Hannover, Germany.
- Ajayi, O.C., S. Franzel, E Kuntashula and F Kwesiga (2003). Adoption of improved fallow soil fertility management practices in Zambia: synthesis and emerging issues. *Agroforestry systems* 59 (3): 317-326. [doi:10.1023/B:AGFO.0000005232.87048.03](https://doi.org/10.1023/B:AGFO.0000005232.87048.03)
- Ajayi, O.C. and F. Kwesiga (2003). Implications of local policies and institutions on the adoption of improved fallows in eastern Zambia. *Agroforestry systems* 59 (3): 327-336. [doi:10.1023/B:AGFO.0000005233.32309.e4](https://doi.org/10.1023/B:AGFO.0000005233.32309.e4)
- Ayuk, E.T. (1997). Adoption of agro-forestry technology: The case of live hedges in the central plateau of Burkina Faso. *Agricultural Systems* 54(2): 189-206. [doi:10.1016/S0308-521X\(96\)00082-0](https://doi.org/10.1016/S0308-521X(96)00082-0)
- Bekunda M.A., A. Bationo and H. Ssali 1997. Soil fertility management in Africa: A review of selected research trials. Pp. 63–79. In R.J. Buresh, P.A. Sanchez and F. Calhoun (eds.) *Replenishing Soil fertility in Africa*. SSSA. Special Publication No. 51, Soil Science Society of America, Madison, Wisconsin, USA.
- Chirwa, T.S., P.L. Mafongoya and R. Chintu (2003). Mixed planted fallows using coppicing and non-coppicing tree species for degraded Acrisols in eastern Zambia. *Agroforestry systems* 59 (3): 243-251. [doi:10.1023/B:AGFO.0000005225.12629.61](https://doi.org/10.1023/B:AGFO.0000005225.12629.61)
- Flett R., F. Alpass, S. Humphries, C. Massey, S. Morriss. and N. Long (2004). The technology acceptance model and use of technology in New Zealand dairy farming. *Agricultural Systems* 80: 199-211. [doi:10.1016/j.agsy.2003.08.002](https://doi.org/10.1016/j.agsy.2003.08.002)
- Franzel S., D. Phiri and F. Kwesiga 2002. Assessing the adoption potential of improved fallows in eastern Zambia. Pp. 37–64. In Franzel S. and S.J. Scherr (eds.) *Trees on the Farm: Assessing the Adoption Potential of Agroforestry Practices in Africa*. CAB International, Wallingford, UK.

- Franzel, S., R. Coe, P. Cooper, F. Place and S.J. Scherr (2001). Assessing the adoption potential of agroforestry practices in sub-saharan Africa. *Agricultural Systems* 69: 37-62. [doi:10.1016/S0308-521X\(01\)00017-8](https://doi.org/10.1016/S0308-521X(01)00017-8)
- Haggblade, H., G. Tembo, and C. Donovan. 2004. *Household level financial incentives to adoption of conservation agricultural technologies in Africa*. Working Paper No. 9, Food Security Research project, Michigan State University, Lusaka, Zambia. 23 pp.
- Howard, J.A. and C. Mungoma. 1996. *Zambia's stop-and-go revolution: the impact of policies and organizations on the development and spread of maize technology*. MSU International Development Working Paper No. 61, Department of Agricultural Economics and Department of Economics, Michigan State University, East Lansing, Michigan 48824-1039, U.S.A. 43 pp.
- Kwesiga, F., S. Franzel, P. Mafongoya, O.C. Ajayi, D. Phiri, R. Katanga, E. Kuntashula and T. Chirwa. 2005. *Successes in African Agriculture: Case Study of Improved Fallows in Eastern Zambia*. Environment and Production Technology Division (EPTD) Discussion Paper No. 130, IFPRI, Washington DC. 75 pp.
- Kwesiga, F.R., S. Franzel., F. Place, D. Phiri and C.P. Simwanza (1999). *Sesbania sesban improved fallow in eastern Zambia: Their inception, development and farmer enthusiasm*. *Agroforestry Systems* 47: 49–66. [doi:10.1023/A:1006256323647](https://doi.org/10.1023/A:1006256323647)
- Kwesiga, F. and R. Coe (1994). The effect of short rotation *Sesbania sesban* planted fallows on maize yield. *Forest ecology and management* 64: 199–208. [doi:10.1016/0378-1127\(94\)90294-1](https://doi.org/10.1016/0378-1127(94)90294-1)
- Mafongoya, P.L., R. Chintu, T.S. Chirwa, J. Matibini and S. Chikale (2003). Tephrosia species and provenances for improved fallows in southern Africa. *Agroforestry systems* 59 (3): 279-288. [doi:10.1023/B:AGFO.0000005228.57515.54](https://doi.org/10.1023/B:AGFO.0000005228.57515.54)
- McDonald, D.G. and C.J. Glynn (1994). Difficulties in measuring adoption of apple IPM: A case study. *Agriculture Ecosystems and Environment* 48: 219–230. [doi:10.1016/0167-8809\(94\)90104-X](https://doi.org/10.1016/0167-8809(94)90104-X)
- New Partnership for African Development (NEPAD). 2003. Comprehensive African Agriculture Development Programme (<http://www.nepad.org>).
- Otsuka, K. and F. Place 2001. *Land Tenure and Natural Resource Management- A Comparative Study of Agrarian Communities in Asia and Africa*. John Hopkins University Press. 389 pp.
- Peterson, J. 1999. *Zambia Integrated Agro-forestry Project (ZIAP) Baseline Survey*. World Vision/University of Florida, Gainesville, Florida, USA. 103 pp.

- Place, F., M. Adato, P. Hebinck and M. Omosa. 2003. *The Impact of agroforestry-based soil fertility replenishment practices on the poor in western Kenya*. FCND Discussion Paper no. 160, IFPRI, Washington. 65 pp.
- Sanchez, A. Pedro (1999). Improved fallows come of age in the tropics. *Agroforestry Systems* 47: 3–12. [doi:10.1023/A:1006287702265](https://doi.org/10.1023/A:1006287702265)
- Scherr, S.J. and E.U. Müller (1991). Technology impact evaluation in agroforestry projects. *Agroforestry systems* 13: 235-257. [doi:10.1007/BF00053581](https://doi.org/10.1007/BF00053581)
- Schroth G. and F.L. Sinclair. 2003. Impacts of trees on the soil fertility of agricultural soils. Pp. 1-9. In Schroth G. and F.L. Sinclair (eds.) *Trees, Crops and Soil Fertility* CAB International, UK.
- Scoones, I. and C. Toulmin. 1999. *Policies for Soil Fertility Management in Africa*. A Report Prepared for the Department for International Development (DFID), International Institute of for Environment and Development (IIED), London, United Kingdom, 128 pp.
- Smaling, E.M.A., S.M. Nandwa and B.H Janssen 1997. Soil fertility in Africa is at stake. Pp. 47-62. In Buresh, R.J., P.A. Sanchez and F. Calhoun (eds.) *Replenishing Soil fertility in Africa*. SSSA. Special Publication No. 51, Soil Science Society of America, Madison, WI.
- Tilman, D., S. Polasky and C. Lehman (2005). Diversity, productivity and temporal stability in the economies of humans and nature. *Journal of Environmental Economics and Management* 49: 405–426. [doi:10.1016/j.jeem.2004.03.008](https://doi.org/10.1016/j.jeem.2004.03.008)

Received: _____

Revised: _____

Accepted: _____

Tables

Table 1: Number and distribution of farmers selected for the study

Agricultural district	Type of farmer		Gender		All
	Agroforestry farmers	Non agroforestry farmers	Female	Male	
Chipata North	52	26	43	35	78
Chipata South	48	23	35	36	71
Katete	42	23	27	38	65
Chadiza	34	23	25	32	57
Petauke	26	5	11	20	31
Total	202	100	141	161	302

Table 2: Major agricultural constraints mentioned by farmers

Type of constraint	% female respondents N=141	% male respondents n=161	Overall % n=302
Lack of cash to purchase inorganic fertilizers	74	61	67
Poor soil fertility	66	59	62
Poor rainfall	33	30	29
Inadequate labor	25	26	28
Lack of farm equipment	12	19	16
Lack of seed	14	13	13
Lack of oxen	5	10	8
Lack of market	6	8	7
Soil erosion	3	7	5
Pest & diseases	5	3	4
Fire outbreak	2	5	4
Inadequate land	5	3	4
Late delivery of fertilizer	1	4	3
Others	12	12	13

Note: Some respondents mentioned more multiple constraints

Table 3: Farmers' assessment of status of fertility of soils in Zambia

Fertility status	% agroforestry farmers	% of non agroforestry farmers	Overall %
Very good	2	7	3
Good	11	16	13
Moderate	44	29	39
Poor	17	21	19
Very poor	26	27	26
Total	100	100	100

Table 4: Perceived advantages and challenges of agroforestry compared with mineral fertilizers

Advantage and challenges of fertilizer tree fallows	% of agroforestry farmers	% of non-agroforestry farmers
Advantages		
Cheaper- “free, we don’t buy it”	65	30
Fertility lasts beyond one season	40	19
Has multi-purpose uses	30	6
Improves soil biophysical properties	21	13
Cash from sale of seeds	7	6
Does not destroy the soil	6	4
Challenges		
Incidence of bush fires	37	6
Pests problems	21	3
Too much labor	18	6
Long wait period	12	8
High mortality of tree seedlings	11	-
Livestock browsing	10	2
Requires bigger land	7	3
Inadequate seed	4	-

Note: Some respondents gave multiple responses

Table 5: Advantages and constraints associated with mineral fertilizers

Type of advantage & constraint	% of AF farmers	% of non-AF farmers
Advantages		
Bumper crop harvest	68	100
Immediate action	86	46
More effective	23	20
Less labor	11	5
Vigorous crops	1	10
Constraints		
It “spoils” the soil	72	34
Requires continuous application	36	21
Costly and requires cash	27	26
Easily leached by rain	9	13
Very expensive	10	9
Wastage if rainfall is poor	7	4

Note: Some respondents listed multiple challenges

Table 6: Farmers' criteria for assessing adoption of agroforestry

Farmers' indicator	% of AF farmers	% of non- AF farmers
Good management of agroforestry field	38	40
Visible impact of household: farmer now sells maize instead of buying	26	41
Density of tree species planted	37	17
Practicing the technology continuously for several years	31	19
Size of field devoted to agroforestry	10	2
Train/educate fellow farmers & attend agroforestry meetings on voluntary basis	10	6
Other indicators	15	5

Note: Some respondents mentioned more multiple constraints

Table 7: Impact of fertilizer tree fallows on households in Zambia

Type of impact	% of female farmers	% of male farmers	%Overall percentage
Increased maize yield	55	55	55
Soil is now better ('softer')	35	34	34
Problem of fuelwood reduced	25	30	28
Cash income from sale of AF seed	7	6	6
Reduction in fertilizer expenses	3	7	5
None yet, started recently	37	34	35
Used as pesticide	3	5	4
Other reasons	21	14	18

Note: Some respondents listed multiple challenges

Table 8: Reasons for *not* planting fertilizer tree fallows

Reason for not planting	% of female farmers	% of male farmers	Overall %
Lack of land	26	30	28
Lack of agroforestry seed	20	31	26
Don't know the benefit yet	15	13	14
Too much labor	11	6	8
Long wait period	4	9	7
No personal land	4	9	7
No knowledge	7	6	6

Table 9: Reasons for preferring specific agroforestry species

Reason	% of female farmers	% of male farmers	Overall %
Good biomass	60	62	61
Ease of plant establishment	18	11	15
Ability to re-grow after cutting	6	11	9
No other species available	6	5	6
Can sell its seeds for cash	5	5	5

Note: Some respondents listed multiple challenges