Farmers' Perception of two Agroforestry Species and their Contribution to Soil Fertility Replenishment in Malawi

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Abstract

A study was conducted in Zomba, southern Malawi, to evaluate the on-farm contribution of agroforestry to soil fertility replenishment in maize-based cropping systems. In this study, two agroforestry species (Gliricidia sepium and Sesbania sesban) were established on 38 farmers' fields that were participating in the researcher-designed and farmer-managed (Type 2) and 50 farmers fields the in farmer-designed and farmer-managed (Type 3) trials. A field survey was undertaken to gauge farmers' innovations and perceptions of mixed intercropping with Gliricidia and relay cropping with Sesbania. The results have indicated a significant increment in maize yields after 2 or 3 years of tree establishment. In the third year of tree establishment, the application of tree biomass significantly increased maize grain yields ($P \leq 0.001$). Gliricidia gave the highest yields compared with all the other treatments. Both species yielded between 1 and 1.3 t ha^{-1} more maize than the farmers' practice. The findings from the Type 3 trials showed that 52% of the farmers have land holding sizes of <1ha and most of the households have a high potential of labour supply. It is further indicated that 92% of the farmers, mostly women, had pruned their trees. Seventy-eight percent (78%) of the farmers confirmed that they have benefited from the technologies. Only 30% of farmers have expanded the original plots and most of these are women farmers (65%). The type 2 trials gave a similar trend of results on household characteristics, except for land holding sizes. Forty-six percent (46%) of the farmers expanded their plots. On tree preferences, >90% of the respondents indicated having high interest in Gliricidia and 54% in Sesbania. This shows that these two technologies have high potential for adoption, with Gliricidia having the highest potential. Our experience revealed that farmer's preference also depends on the position of farmland on the soil catena.

Introduction

Low soil fertility and crop yields rank high among the constraints to smallholder food production in Malawi. The situation is exacerbated by the fact that farmers cannot afford to purchase chemical fertilizers to replenish the nutrients removed through crop harvests and loss due to soil erosion. Incorporating organic residues into the soil is widely practiced in southern Malawi. The most conventional nutrient sources, such as crop weeds and residues, however, are low in N and other nutrients (Kanyama-Phiri et al., 1998; Tian et al., 1993).

Studies from southern Africa (Kwesiga and Coe, 1994; Kwesiga et al., 1999) have demonstrated the potential of *Sesbania* as a source of N when grown in rotation with maize. *Sesbania* nodulates heavily and can fix up to about 100-350 kg of atmospheric N ha^{-1} yr^{-1} (Brewbaker et al., 1990). *Gliricidia* is used in view of its superior growth and biomass N production in Malawi and high N contribution from its foliage (Maghembe and Prins, 1994). Studies have shown that *Gliricidia* can yield over 5.4 tons per ha per year of coppiced biomass (Maghembe and Prins, 1994). The benefits of incorporating tree foliage into the soil are well known. These include an increase in soil organic matter and nitrogen contents, and improvement in soil physical characteristics, such as aeration, permeability and soil bulk density. Agroforestry systems, namely mixed intercropping of *Gliricidia sepium,* and *Sesbania sesban* relay cropping with maize, were developed to allow farmers in the Shire highlands, and other highly populated areas, to use these for soil fertility improvement, while cultivating their land continuously without fallowing. In addition, the improved fallow

system has been introduced in central and northern Malawi where land holding sizes are relatively large.

Results from 8 years of field experimentation with mixed intercropping and relay cropping technologies at Makoka (Akinnifesi and Kwesiga, this proceedings) have shown a significant increase in maize yields over a long period of time, and this has necessitated the testing of these technologies under smallholder farmers' field conditions. Testing the technologies with farmers provides an opportunity for understanding farmers' reasons for adopting the technologies and their potential for adaptation. Technology adoption is associated with profitability of the technology and the farmers' household characteristics, labour availability, gender and landholding sizes. This study was undertaken to evaluate: (i) the biophysical performance of mixed intercropping and relay cropping technologies under farmer management, (ii) farmer's perception on the expansion of the technologies and dissemination pathways, and (iii) farm and household characteristics associated with the adoption of the technologies.

Materials and Methods

Study Site

The study was conducted in farmers' fields in Thondwe, Dzaone and Malosa Extension Planning Areas (EPA) near Zomba, southern Malawi (15° 30'S; 35° 15'E). The area is situated at about 1,000 m asl and the annual total rainfall varies from 850 to 1,250 mm per year with a mean of about 1,000 mm per year. The rainy season lasts from November to April followed by a dry season from May to October.

Experimental Design

The study was undertaken with 88 farmers in two types of trials: (i) Type II trials which are researcher-designed but farmer-managed, and (ii) Type III trials, based on farmers' understanding of the technology, which are farmer-designed and farmers-managed. Type II research was developed to assess both the biophysical data and farmer management. Type III trials were designed to assess the farmers' adaptation of the technologies, potential adoption of the technologies and recommendation domains. The type II trial was undertaken during the 1994/95 to 1999/00 cropping seasons, and was designed as Randomized Complete Block Design (RCBD) in 38 farmers' fields.

Each farmer was a replicate and had three plots (i) *Gliricidia* mixed intercropped with maize (ii) *Sesbania* relay cropping with maize and (iii) maize monocrop. The plot sizes were variable, averaging at least 17x17 m gross, and a net of 10x10 m. The type 3 trials were initiated in the 1995/96 crop season. These were sited at Domasi valley in Malosa EPA and Six Miles in Thondwe EPA. A total of 50 farmers were each given 100 seedlings of both *Gliricidia* and *Sesbania*. Farmers decided where to plant the trees and managed the experimental plots on their own.

Tree Management

Tree seedlings were planted in December 1994 and January 1995 after the maize was fully established for the Type II trials. For Type III trials, the trees were planted in December 1995 and January 1996. The trees were planted in furrows at a spacing of 90 cm within

furrows and 150 cm between furrows. This arrangement allowed a tree row in every other furrow and resulted into a tree population of 7,400 trees per hectare. After maize harvest, the trees were left in the field to grow through the dry season. *Gliricidia* coppices readily when cut, and were intensively pruned back to about 30 cm from the ground to minimize competition for light during the maize-growing season. On average, *Gliricidia* was pruned 3-4 times depending on growth and rainfall.

The trees were pruned in September, November and January each year. In this technology, ridges were maintained in their position, a practice that is different from the traditional system where ridges are shifted annually at each ridging time. *Sesbania sesban* does not coppice readily when cut. Consequently, this species was planted two weeks after maize germination every year and cut down in October when it was 10 months old. In both technologies, leaves and twigs were incorporated into the ridges. **The** wood was separated and used as fire wood and/or construction materials. For *Gliricidia,* the wood was separated only from the first cutback in the season.

Data Collection and Analysis

Agronomic data. The Type II trial was assessed at the end of each cropping season. Data collected included maize yields, leaf biomass and woody biomass. For *Sesbania sesban*, tree biomass was assessed at 10 months by completely cutting the trees in all plots. *Sesbania* leaves were cut manually and incorporated into the soil. Leaf and woody biomass from each net plot were weighed, and a sample from each was taken for moisture content determination. *Gliricidia* biomass was assessed at each pruning every season. During the first pruning, leaf biomass was separated from the woody biomass. However, during the second and third prunings, all the harvested prunings comprised of tender stems and these were all combined as leaf biomass. Maize grain yield was determined at 12.5% MC, and extrapolated to a per hectare basis. All data were subjected to analysis of variance using GENSTAT.

Farmers' Perception

To capture the farmers' perception regarding the technologies, information was collected in a survey using a structured questionnaire. This was done with 33 Type II and 50 Type III farmers. Farmer household characteristics collected included: household size, age, gender, marital status, and education, land holding sizes, livestock ownership and labour utilization. Expansion of land devoted to agroforestry (number and area of trees planted and management practices) was assessed. During the surveys, farmers were asked if they have extended their original plots. On management practices, information was obtained on how the farmers are managing the trees and crops. Information was also obtained on farmer preferences and perceptions. Farmers were also asked to rate the technology and the farmer practice according to by products, management and pest damage. Coded data was entered and analyzed on an SPSS computer programme. Data were summarized into frequencies and percentages and cross tables.

Results and Discussion

Maize Yields and Tree Biomass

Table 1 shows maize and biomass yield from the Type II trial during the 1995/96 - 1999/00 cropping seasons. Leaf biomass was very low in 1996 because of a drought, which was

experienced in the 1994/95 crop season (540 mm) (Figure 1). This drought resulted in poor survival and establishment in the initial year. Significant re-planting of the trees had to be done in December 1995 and January 1996 to obtain a normal stand of trees. The high coefficient of variation in leaf biomass and maize yield can be ascribed to the inherent variation in soil fertility between fields, management differences and different positions along the catena. In general, it was observed that *Sesbania* performed better in the *dambo* (seasonally water logged areas), while *Gliricidia* had problems to establish under these conditions. This performance is, however, reversed in well-drained middle slopes (R. Phiri, unpublished data).

Table 1: Maize yields and tree biomass (kg/ha) in Type II on-farm across five seasons (1995/96-1999/00)*

Treatments	1995/96 (N=40)	1996/97 (N=40)	1997/98 (N=40)	1998/99 (N=38)	1999/00 (N=32)	Mean
Maize yield						
Sole maize	1770	1020	1430	1240	672	1226
Maize + *Gliricidia*	1790	1090	2700	2740	1198	1904
Maize + *Sesbania*	1660	1060	2300	2230	1251	1700
SE (±)	NS	NS	580	750	224	
CV(%)	32	33	27	36	53	
Foliage biomass						
Sole maize	-	-	-		-	-
Maize + *Gliricidia*	540	1860	2190	3940	-	2133
Maize + *Sesbania*	820	1200	1480	1000	-	1125
SE (±)	NS	NS	1000	980		
CV (%)	64	69	55	40		
Wood biomass						
Sole maize	-	-	-		-	-
Maize + *Gliricidia*	-	-	680	1820	-	1250
Maize + *Sesbania*	-	-	780	680	-	730
SE (±)			NS	870		
CV (%)			80	69		

* Foliage biomass for the 1999/00 crop season was not assessed. Wood biomass was only assessed for the 1997/98 and 1998/99 crop growing seasons

Sesbania grew faster and yielded more biomass in the first year than *Gliricidia.* This is because *Gliricidia* grows very slowly in the first year and produces little biomass, and hence low N is returned to the soil, resulting in no maize yield response. In the case of *Sesbania*, the tree grows very fast and can produce significant biomass in 10 months.

During the 1996/97 crop season, there were no significant differences in maize grain yield despite an increase in the amount of leaf biomass applied (Table 1). These results can be attributed to excessive rainfall (1,605 mm) that resulted in flooding during the months of January and February in 1997. In addition to creating anaerobic conditions, excessive soil-water may also have leached nutrient out of the root zone. In the third year of tree establishment, the application of leaf biomass significantly increased maize grain yields ($P \leq 0.001$). *Gliricidia sepium* produced the highest maize grain yields compared with all the other treatments.

This treatment gave about 1, 300 kg more maize than the control; whereas the *Sesbania* treatment gave about 1000 kg more maize grain yield than the control treatment. In the fourth and fifth years, the yield increment followed the same trend as in 1998. However, in the fifth year, yields in all the treatments were low. This can be attributed to prolonged drought during the months of December 1999 and January 2000. The total rainfall received (783 mm) was lower than the forty year average by 227 mm.

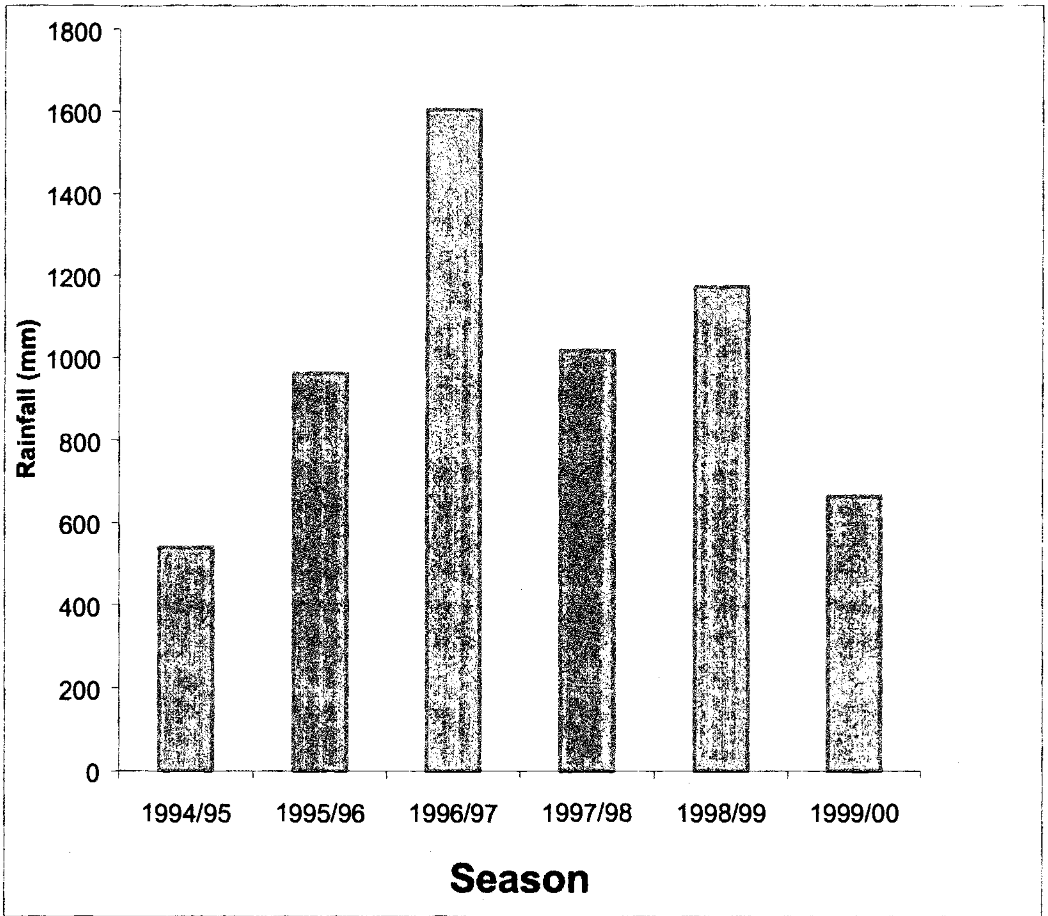

Figure 1: Rainfall distribution for Makoka Research Station for a period of six years (1994/05-1999/00)

Farmer and Household Characteristics

Table 2 shows the profile of the farmers involved in the farmer designed trials. The study shows that 64% of the households are male headed, whereas 32% are female headed. Kamanga (1998) reported similar results in a survey carried out in the Songani area in Zomba. In his study, 66% of the households were male headed. The results of this study agree with those of the Malawi Government (1980) that indicated that 40% of the households' heads in Malawi are females. Gender of household headship may influence the accessibility to farm resources. In the present study, the majority of the farmers are between 20 and 60 years old with an average of 46 years. Kachule (1994), in a survey carried out in south Mzimba found that the majority of farmers were in the age range of 20-64 years and had

higher labour access than the age category of 64 and above. In Malawi, this is the age group that is considered to be of great economic importance in the agriculture sector.

Table 2: Profile of participating farmers

a. Type of household	**Frequency**	**%**
Male headed household	**32**	**64**
Female headed married	**1**	**2**
Female headed single	**15**	**30**
No response	**2**	**4**
Total	**50**	**100**
b. Age group		
20-40	19	38
41-60	17	34
>61	9	18
No response	5	10
Mean age	45.6	100
c. Most educated member		
Attended primary school	26	52
Completed primary school	3	6
Attended secondary school	10	20
Completed secondary school	7	14
Other	2	4
No response	2	4
Total	50	100

The educational level of the most educated member of the household indicates that most of them had at least attended primary school. This means that most households have a member who can at least read or write. Education facilitates communication between farmers and extensionists, and increases the chances of adopting new technologies (Kamanga et al., 1998). Seventy percent (70%) of the farm families were literate meaning that they have 3 or more years of education and 68% of the family heads were able to read and write. Table 3 shows that only 2% of the farmers had less than 0.5 ha of farmland, suggesting that land holding sizes in the project sites were higher than the regional average of 0.4 ha for southern Malawi. Fifty-three per cent (53%) have land that is between 0.5 and 1 ha, whereas some 45% or more than about 1 ha of land.

Off-farm Resources

More than 70% of the farmer's own livestock, the majority of which are mostly chickens. None of the farmers own cattle, which is mainly due to shortage of fodder. Kamanga (1998), in a study carried out around Songani in Zomba found that none of the families had cattle, whereas 56% indicated that they had chickens. Eighty two per cent (82%) of the farmers receive off-farm income and this is mainly from trading.

Farm Inputs

Ninety-two percent (92%) of the farmers applied inorganic fertilizer last season and this was largely applied to the maize crop (Table 4). From informal discussions with the farmers it was noted that most of this fertilizer was from the "Starter Pack Scheme (SPS)". Under SPS

government gives each farmer 10 kg and 5 kg of fertilizer for basal and top dressing, respectively, free of charge. It has been noted, however, that most agroforestry farmers were not considered eligible for the fertilizer incentive in the 2000/01 crop season which was targeted to the poorest of the poor, and this is why SPS for the 2000/01 was renamed "Targeted Inputs Programme (TIP)".

Table 3: Land holding sizes of participating farmers

Farm size	Frequency	%
< 0.5 ha	1	2
0.5-1 ha	25	53
>1 ha	21	45
Total	47	100

Table 4: Participating farmers who applied inorganic fertilizer last season

	Frequency	**%**
Applied fertilizer (Starter Pack)		
Yes	44	92
No	4	8
Total responses	48	100
Crops applied with fertilizer		
Maize	42	95
Tobacco	2	5
Total responses	44	100

Family Labour Distribution and Decisions for Farm Activities

Table 5 shows labour potential and labour supply. The number of people from 1-3 constitutes 64% of the available family labour. Thirty-four percent (34%) have available family labour in the range of 4-6 people. This implies that most of the families have a high potential of labour supply. The data further shows that 45% of the farmers hired labour. Many farmers hired labour for weeding and land preparation purposes. These data do not concur with the findings of ICRA (1987) where only 14% of the total labour force was hired in west Mulanje, showing that most farmers rely on family labour. Thirty five percent (35%) of the farmers sold labour and again this was mostly for weeding and land preparation.

One possible reason why farmers sell their labour for weeding is because this operation is normally done at the time when most farm families have no food, so that one of the available options is to look for ganyu labour employment. The data also shows that 58 % of the people who make major decisions for on-farm activities are the males, whilst 38% of the females are responsible for making major decisions. Both husband and wife make only 4 % of the decisions.

An Assessment of Agroforestry Tree Species

Results on the assessment of agroforestry trees, *Gliricidia sepium, Sesbania sesban*, and *Tephrosia vogelii*, are shown in Table 6.

Table 5: Labour use and major decision for field activities by farmers

	Frequency	%
Available family labour		
>13years	**30**	**64**
1-3	**16**	**34**
4-6	**1**	**2**
>6	**47**	**100**
Total responses		
Hired labour		
Yes	21	42
No	26	52
Total responses	47	100
Sold labour		
Yes	17	35
No	31	65
Total responses	48	100
Major decision taken		
Husband	27	58
Wife	18	38
Other	2	4
Total	47	100

Table 6: Farmers' evaluation of agroforestry tree species

Reason for choosing site	Frequency	%
Low soil fertility	**40**	**87**
Other	**6**	**13**
Total responses	**46**	**100**
Problems with tree establishment		
Yes	43	90
No	5	10
Total responses	48	100

Many farmers (87%) planted the tree species on degraded soils to restore soil fertility. Ninety percent (90%) of the farmers indicated having problems with tree growth, especially with direct sowing. The problem with tree growth can be attributed to late planting, which most farmers often do. Planting with the first rains ensures good tree establishment. Forty-two percent (42%) of the farmers indicated that drought was a problem during the establishment phase. Thirty nine percent (39%) of the trees were attacked by termites, whereas insect pests attacked 12%. None of the farmers reported on the problem of livestock browsing.

This is because few people own livestock, and even for those who own some small stock, such as goats, these are generally tethered throughout the year. Over 80% of the farmers planted the trees in every other furrow as per recommendation. Only few farmers planted on ridges and field boundaries. This shows that most farmers followed the recommended tree spacing.

Tree Management

The information on tree management is given in Table 7. The study shows that 96% of the farmers prune their trees regularly. It has further shown that the tree prunings are managed differently. Fifty six percent (46%) of the farmers incorporate the prunings by opening ridges, 24% apply on the surface, whereas 11% incorporate by opening groves. For those who planted *Gliricidia sepium*, 33% said that they pruned once in a season, 48% pruned twice and only 19% pruned 3 times.

This shows that most of the farmers are not pruning as per recommendations. It has also been shown that 60% of those who pruned the trees are women and 35% are men. This concurs with other studies (Wermer, 1987; Enberg et al., 1993; Malawi Government, 1993) that indicate that women farmers are increasingly taking up smallholder agricultural activities, including agroforestry.

Fifty five percent (55%) of the respondents did not experience any problems with pruning, whilst 45% faced problems with the pruning operations. Of those who faced problems with pruning, 52% said the problem was lack of pruning tools, 24% time consuming, and some 5 % said it is labour intensive. These results are contrary to expectations, because it has always been alleged that labour is the main constraint to the adoption of agroforestry technologies. This is probably because most of them did not prune 3-4 times as has been recommended, and also because most of the families have high labour potential supply in the study areas.

Only 32% of the farmers reported that they are keeping the trees for seed production compared with 68 % who were not keeping them for seed. This shows that most of farmers are still relying on seed sources from outside their areas, and this has contributed to lack of expansion of agroforestry plots, since seed is a limiting factor.

Table 7: Tree management practices followed by the farmers

Parameter	Frequency	%
Pruning frequency		
Once	**15**	**33**
Twice	**22**	**48**
Thrice	**9**	**19**
Total responses	**46**	**100**
Pruning management		
Incorporate by opening ridge	**25**	**56**
Incorporate by opening grooves	**5**	**11**
Apply on the surface	**11**	**24**
Other	**4**	**9**
Total responses	**45**	**100**
Type of pruning problems		
Time consuming	**5**	**24**
Lack of tools	**11**	**52**
Too much labour	**1**	**5**
Other	**4**	**19**
Total responses	**21**	**100**
Tree for seed production		
Yes	15	32
No	32	68
Total response	47	100

Benefits from the Technologies

About 78% of the farmers have reported benefits from the use of agroforestry technologies (Table 8). The majority of those who benefited (48%) were those who reported an increase in maize yields only. Twenty six percent (26%) reported benefits accruing from the sale of both maize and firewood, whereas 20 % had other benefits, which included the sale of seed and construction materials, and 6% reported benefits in the form of firewood only.

None of the farmers benefited from the trees after 1 year of tree establishment (Table 8). However, 58% reported some benefits after 3 years, and 42% after 2 years of tree establishment. These findings are consistent with previous research findings where it has been observed that farmers start getting significant increases in maize yield after 2 to 3 years after tree establishment (Maghembe and Prins, 1994).

Expansion and Dissemination of Technologies

The mean plot sizes of each tree species planted at the beginning of the experiment was 271 m^2. The results indicate that only 35% of the farmers have expanded from the original plot. Lack of seed was often given as the main reason why many farmers did not expand their plots. The farmers who have expanded, have more than doubled or tripled the original plot sizes. The data also shows that more women farmers expanded their plots than men farmers. For instance, 64% of the women expanded their plots compared with only 35% of the men farmers. This indicates that women farmers have a high potential of adopting agroforestry technologies than the men farmers.

Table 8: Farmers' benefits from agroforestry technologies

Parameter	Frequency	%
Benefits from technology		
Yes	39	78
No	8	16
Not sure	3	6
Total responses	50	100
Type of benefits		
Maize yield increment only	24	48
Firewood only	3	6
Both maize and firewood only	13	26
Other	10	20
Total responses	50	100
Period taken to get benefits		
1-year after tree establishment	0	0
2-year after tree establishment	21	42
3-year after tree establishment	29	58

Table 9: Gender in relation to technology expansion

Gender	Expanded	Not expanded	Total
Male	35	65	100%
Female	64	36	100%

Fifty-four percent (44%) of the farmers have shared information on the agroforestry technologies with relatives and/or friends. The information shared includes the benefits of the technologies, the acquisition of seeds or seedlings, and management of the technologies at farm level.

Preference of Agroforestry Technologies

The farmers ranked technology preference with respect to use, management and damage by pest. Overall, 97% of the farmers are interested in *Gliricidia sepium* and 54 % in *Sesbania sesban*. This shows that both tress species have high potential for adoption.

Conclusions

The results obtained from the 5 year on-farm research on *Gliricidia* and *Sesbania sesban* technologies have shown that during the first year of tree establishment biomass is fairly low, more especially with *Gliricidia sepium*. In the subsequent years, biomass increases steadily. This means that the technologies are quite sustainable. Under farmer's conditions, there has been a significant increase in maize yields resulting from the use of agroforestry technologies. The increase in maize grain yield is directly related to the amount of biomass incorporated. It has also been found out that biomass production and maize response are greatly influenced by rainfall.

The survey results have shown that most of the households who are participating in the agroforestry trials have a high potential of labour supply. This has also been reflected in the high percentages of farmers who are pruning the trees. So far, the farmers are following the researchers recommendation of managing the trees, especially the number of tree prunings in a year. The survey has further revealed that most farmers start getting the benefits of the technologies only after 2-3 years of tree establishment. Most of the farmers who have expanded their original plots are women. This indicates that there is potential for the adoption of the technologies, and that women farmers, have the greatest potential. Those who have not expanded their plots have indicated the lack of seed or seedlings as the main constraint. Germplasm supply and delivery pathways should receive greater attention in these farmer-led agroforestry initiatives. What we have observed is that some farmers have developed expectations for free seedlings or seeds. Therefore, a way should be sought to avoid dependency on free seedlings. There is need to validate these findings with the use of other methodologies, such as the used of focus group interviews and matrix ranking.

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