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Full Length Research Paper

Farmer participatory assessment of two researcher-managed ‘fertilizer tree systems in Southern Malawi

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The suitability of maize under two fertilizer tree fallow systems were evaluated by farmers at Makoka Agricultural Research Station in southern Malawi. Sixty-eight farmers drawn from five farmer groups assessed Gliricidia-maize intercropping system, and 72 farmers assessed rotational fallows with 10 trees species during 2001. Fertilizer treatments and maize plots served as controls. Gliricidia-maize plot without fertilizer amendment and maize fertilized with 50% of the recommended N doze in Gliricidia-maize intercropping were judged as "best" by the majority (60-71%) of farmers involved in assessing the technologies in groups as well as individuals. Among the rotational fallows, the majority of farmers had ranked maize cropped after *Tephrosia vogelli*, *Gliricidia sepium* and *Sesbania sesban* higher than with fertilized monoculture maize. The unfertilized maize plot was adjudged unsuitable by 96% of the farmers. Maize plots supplied with 50% of the recommended N dose were less preferred to unfertilized Gliricidia-maize plots.

Key words: Nitrogen-fixing trees, agroforestry, farmer preferences, fertilizer supplementation, Malawi.

INTRODUCTION

Combating declining soil fertility and increasing food productivity are two major research and development goals in addressing the recurrent food insecurity and income poverty in sub-Saharan Africa. This is particularly so for Malawi, where the resource-base is extremely fragile and rural poverty is extensive. The negative effects of soil depletion extend beyond farming households into communities and on to a national and regional scale (Sanchez et al., 1997). The use of chemical fertilizers by smallholder farmers is severely constrained by inadequate supply due to delivery problems and prohibitive costs (Akinnifesi et al., 2006, 2007). Therefore, use of organic matter technologies involving nitrogen-fixing legumes has become an important option for increasing soil fertility and maize yields in sub-Saharan Africa (Sanchez et al., 1997; Snapp et al., 2002). This is due to its ability to build soil fertility capital *in-situ*, eco-friendliness and low direct costs to farmers.

One of the main tenets of organic matter technologies is that legumes contribute to soil fertility and the long-term sustainability of the system because of the ability of legumes to fix atmospheric nitrogen (Adu-Gyamfi et al., 2007). Increasingly, the nutrients produced from cereal-legume systems are insufficient in quantity and quality to meet crop demands (Kwesiga et al., 2003; Mafongoya et al., 2006; Akinnifesi et al., 2007). Alternative nutrient sources from nitrogen fixing tree legumes (fertilizer tree systems) have been researched in the last two decades (Kwesiga et al., 2003). Fertilizer tree systems have been designed with variants and options for farmers to manage in space and time. The variants include i) Gliricidia (*Gliricidia sepium*)-maize intercropping (Akinnifesi et al., 2006, 2007), ii) annual relay cropping involving short-rotation shrubs such as *Cajanus cajan*, *Tephrosia spp*. and *Sesbania sesban* (Ikerra et al., 1999; Harawa et al., 2006), iii) short-rotation fallows using non-coppicing leguminous trees and shrubs (Kwesiga et al., 2003), and biomass transfer (Kuntashula and Mafongoya, 2005).

Acceptability and adoption of a new technology involves not only biophysical and economic profitability, but also requires adequate knowledge of a number of factors

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including how users perceive the underlying problem, their attitude, beliefs and practices related to the solutions offered to them by the technological innovation (Franzel et al., 2001; Ajayi, 2007, Ajayi et al., 2007). 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 (Ajayi, 2007). On-farm experimentation and surveys have been widely used because they provide useful information on farmer's needs, circumstances, problems, preferences, and management strategies (Franzel et al., 1995). However, much less attention has been focused on farmer participatory evaluation of on-station experiments.

Recently, participatory research methods have been advocated as means of improving relevance and adoption of agroforestry technologies (Kuntashula and Mafongoya, 2005). Participatory methods that document farmers' perceptions early in the research process are expected to improve the relevance of technologies and to seek partnerships with them in developing technologies. This methods are also assumed to elicit a complementary understanding of the *emic* (insider — in this case farmer) and *etic* (outsider — in this case the scientist) perspectives of problems and solutions (Sileshi et al., 2008). This paper therefore, describes the findings from farmers' participatory evaluation of agroforestry experiments on a research station. The specific objectives of the study were: 1) to determine farmers' preference and perceptions of different species along with sole maize and N fertilizer managed in on-station trials, and 2) to understand farmers' criteria in assessing soil fertility management treatments, in order to complement the long-term biophysical assessments by researchers.

MATERIALS AND METHODS

Study site description

The trials were located at the Makoka Agricultural Research Station in southern Malawi (15° 30' S, 35° 15' E; altitude 1030 m, a.s.l.). The soil is classified as Ferric Lixisol (FAO/UNESCO). The soil characteristics and nutrient dynamics have been described elsewhere (Ikerra et al., 1999). The total annual rainfall ranges from 560 to 1600 mm, with a 30-year mean of 1024 mm (Akinnifesi et al., 2006). The rainfall is unimodal, and most of the rains occur in November-April. The cropping season extends from late October to April.

Experiment 1: Gliricidia-maize intercropping

The experiment was established in December 1991. The trees were cut back about one year after planting. The experiment is a randomized complete block design with three blocks. Each treatment was replicated thrice. For the purpose of this study, the following six treatments were selected: (1) Monoculture maize without nutrient inputs (Control), (2) Monoculture maize with 50% of the recommended N dose (46 kg N ha^{-1}), (3) Monoculture maize with 25% of the recommended N dose (23 kg N ha^{-1}), (4) Maize-Gliricidia intercropping without fertilizer, (5) Maize-Gliricidia intercropping amended with 50% of the recommended N dose (46 kg N ha-1), and (6) Maize-Gliricidia intercropping amended with 25% of the recommended N dose (23 kg N ha^{-1}). The recommended N rate for southern Malawi is 92 kg N ha^{-1} by side dressing. Fertilizer was applied to the maize crop only. There was no treatment with fully fertilized maize at the time of the experiment during the first ten years of the long-term trial, as the original trial was to examine the contribution of micro-dozes of mineral N fertilizer to sole maize and Gliricidia-maize innovation (Akinnifesi et al., 2006).

Gliricidia (*G. sepium* (Jacq.) Walp (ex Retalhaleu, Guatemala provenance) was used in view of its superior growth in Malawi. The trees were established from seedling stock in December 1991, without cropping. Gliricidia plots consisted of four rows of trees planted in every other furrow at 90 cm within tree rows and 150 cm between tree rows (7400 trees ha^{-1}s). Plot size was 6.75 x 5.1 m, separated by 1-m wide path.

The trees were pruned three times during each cropping season. The pruning cycle of September-December-February was repeated continuously. Tree management has been described in detail in Akinnifesi et al. (2006, 2007) and Makumba et al. (2006). Maize hybrid NSCM 41 was planted on ridges at a spacing of 30 cm within rows and 75 cm between rows (44,000 plants ha^{-1}), in both the monoculture maize as well as intercropping. Maize was weeded twice by hand during the cropping season typical of the traditional farming practice.

Experiment 2: Rotational fallow trial

The rotational fallow trial had 14 treatments arranged in a randomized complete block design with three replications. The treatments consisted of (1) *S. sesban* (locally known as "Jere jere"); (2) *Sesbania macrantha*; (3) *Tephrosia vogelli* (locally known as "mtutu" or "katupe"); (4) *Gliricidia sepium*; (5) *Ateleria herbertsmithin;* (6) *Crotolaria juncea*; (7) *Tithonia diversifolia* (8) *Aesynomene americanum*; (9) *Calliandra calothyrsus*; (10) *Tephrosia candida*; (11) Continuous maize cropping without fertilizer; (12) Continuous maize cropping with fertilizer; (13) Natural fallow with fertilizer, and (14) Natural fallow without fertilizer. The fertilizer was a full N doze (92 kg N ha^{-1}) from Calcium Ammonium Nitrate and full P doze (40 kg P ha-1) from triple super phosphate (TSP). The trees/shrubs were left to grow as fallows for three seasons (1998-2000). At the end of the fallow period, the trees/shrubs were clear-felled. The prunings and litter, accumulated during the two seasons were incorporated into the soil. All plots were planted with maize and pigeon pea intercrop. Four maize seeds were planted per hole spaced at 90 cm between hills. Four pigeon pea seeds were planted per hole in between the maize hills. Both crops were thinned to 3 plants per station 3 weeks after planting.

Farmer's selection and assessment

From January to April 2001, farmers were brought in separate groups to the Makoka Agricultural Research Station, to evaluate the performance of the two trials. The major ethnic groups of the study sites are the *Lomwes* (Thyolo and Chiradzulu) and the *Yaos* (Machinga). Both ethnic groups speak Chichewa national language.

In total, 68 farmers (27 women) involving five farmers groups from six villages in five Extension Planning Areas (EPAs) participated in evaluating the performance of the six treatments in Gliricidia-maize intercropping (Table 1). Similarly, a total of 72 farmers (35 females) drawn from three Extension Planning Areas (EPA) of Malosa, Thondwe, and Mombezi (Table 2) evaluated the three year improved fallow. The farmers included those who collaborated directly with ICRAF on agroforestry testing and adaptation and

Table 1. Farmers participating in evaluation of Gliricidia-maize intercropping at Makoka.

Farmer Groups	Extension Planning Area	Farmers		Total
		Male	Female	
1	Khonjerani	9	5	14
2	Thyolo	2	4	6
3	Mbulumbuzi	14	9	23
4	Mombezi	4	3	7
5	Nanyumbu	12	6	18
Total		41	27	68

Table 2. Farmers participating in evaluation of improved rotational fallow on station (n = 72)

Farmer group	EPA	Farmers		Totals
		Male	Female	
1	Malosa	3	4	7
2	Thondwe	4	4	8
3	Mombezi (Chiradzulu) (DAPP) †	4	4	8
4	Mombezi (Chiradzulu) (PROSCARP) ††	26	23	49
Total		37	35	72

†Development Aid from People to People (DAPP); ††Promotion of Soil Conservation and Rural Production (PROSCARP).

those who participated in agroforestry activities indirectly through national partners. Each group of farmers from the same area or organization visited and evaluated the on-station trials on separate days. Before assessing the treatments, the background, objectives and management of the trials were explained to the farmers in the local Chichewa language.

Individual farmers' rating

Each field treatment was given its code for identity and a 1-5 scale scoring code was developed for the performance of the plots: 1 = very poor or least, 2 = poor, 3 = fair; 4 = good and 5 = very good or best. These were explained using the local language *(Chichewa)* translations. Farmers were guided by extension officers to each plot /treatment and asked to rate each treatment based on their perception and judgment on the stand's performance with respect to maize leaf colour, plant vigour and cob size.

Group voting (repertory grid)

The second approach used the repertory grid method. The farmer groups that came for field days from four EPAs (n =116 farmers) were asked to rank the rotational fallow plots in groups. The farmers were shown the selected treatments in replicates of three, and then asked to evaluate the treatments. Where a lead farmer could not be easily identified, an extension officer helped by leading plenary discussions which were concluded with a vote, through showing of hands. The criteria by which farmers evaluated the treatments were elicited from the group discussions while farmers were visiting and observing the plots. The farmer groups therefore evaluated the agroforestry technologies and ranked them based on their preference of the technologies and the reasons why they preferred those technologies.

A ranking form was given to every farmer with a table of treatments and the ranking codes. Farmers were asked to rank the treatments basing on their perception and judgment on the stand's performance at mid reproductive maturity (when cobs were green but matured). The process was followed for each replicated of the trials.

Data analysis

The qualitative information was summarized and tabulated. For analyzing farmers' individual rating of treatments as poor, good or best, a generalized linear model assuming multinomial logistic error distribution of the ranking was used. For this analysis, three categories (i.e. poor, good and best) were identified by combining and recoding poor and very poor as "poor", fair and good as "good" and very good as "best". Therefore, the cumulative logit model was used and parameters were estimated using the LOGISTIC procedure of the SAS system. "Poor" was used as the reference category among the ranks. Similarly, among the treatments monoculture maize without fertilizer (control) was used as the reference category. Mean rank order scores were calculated as follows: if the treatment was mentioned as best or excellent it receives a value of 5, very good receives 4, good receives 3, fair receives 2 and poor receives zero. The mean rank order is the mean of all values including zeros. The mean rank order scores were then analyzed using a non-parametric test. The PROC NPAR1WAY procedure of the SAS system was used to computes the corresponding linear rank and one-way ANOVA tests. PROC NPAR1WAY computes exact tests, which are appropriate when a data set is small, sparse, skewed, or heavily tied. The statistical significance and mean rank scores of Wilcoxon

Table 3. Farmers' individual ranking[†] treatments in the Gliricidia-maize intercropping system

Treatment	% Times farmers ranked			
	Very poor or poor	Fair or good	Very good	Overall ranking
Gliricidia-maize + 50% RNF[†]	5.9	82.4	70.6	1
Gliricidia-maize without fertilizer	4.4	83.8	52.9	2
Gliricidia-maize + 25% RNF	7.4	79.4	45.6	3
Monoculture maize + 50% RNF	22.1	14.7	2.9	4
Monoculture maize + 25% RNF	48.5	8.8	5.9	5
Monoculture maize without fertilizer	86.0	1.5	1.5	6

[†] Multiple choices possible, so percentage data did not sum to 100 in row or column

[†] RNF=Recommended Nitrogen Fertilizer dose.

Table 4. Parameter estimates of the logistic regression analysis of farmers' assessment of the treatments in the maize-Gliricidia intercropping.

Parameter	Parameter Estimate	Lower 95% CL	Upper 95% CL	Chi-square	Probability
Intercept 1 (Best)	-1.62	-1.99	-1.26	76.2	<0.0001
Intercept 2 (Good)	1.06	0.68	1.44	30.3	<0.0001
Intercept 3 (Poor)	--	--	--	--	--
Sex (Female)	0.04	-0.18	0.26	0.1	0.7419
Sex (Male)	--	--	--	--	--
Maize-Gliricidia + 50% RNF[†]	2.52	1.96	3.08	78.4	<0.0001
Maize-Gliricidia without fertilizer	1.80	1.29	2.32	47.2	<0.0001
Maize-Gliricidia + 25% RNF	1.50	1.00	2.01	33.9	<0.0001
Monoculture maize + 50% RNF	-0.28	-0.78	0.23	1.2	0.2807
Monoculture maize + 25% RNF	-1.11	-1.63	-0.58	16.9	<0.0001
Monoculture maize without fertilizer	--	--	--	--	--

[†] RNF=Recommended Nitrogen Fertilizer dose.

Intercept 3 (Poor), sex male, and monoculture maize without fertilizer were held as the reference categories (0)

test are presented.

RESULTS

Farmers assessment of Gliricidia-maize system

Individual farmers' rating: Table 3 shows individual farmers' ranking of maize performance in the various treatments in the Gliricidia-maize intercropping field at Makoka. Overall, the majority of farmers ranked Gliricidia-maize intercropping plots with 50% N fertilizer dose as the "best" and continuous maize without fertilizer as the least (Table 3). Gliricidia-maize amended with 50% of the recommended fertilizer dose was ranked "very good" by 71% of the farmers. Gliricidia-maize without fertilizer amendment was ranked "very good" by 53% of the farmers. Less than 6% of all farmers ranked monoculture maize as "very good" even when the maize has received 50% of the recommended fertilizer. Over 86% of the farmers ranked unfertilized monoculture maize as poor (Table 3).

The logit-linear model gave 81.3% correct classification, and indicated significant difference between treatments ($\chi^2 = 134.1$, df = 5; $P < 0.0001$) in farmers ranking. There was no difference between female and male farmers in the ranking of treatments (Table 4). Examination of the 95% confidence intervals (Table 4) confirms the differences between treatments. The 95% confidence intervals for all the Gliricidia-maize intercrop treatments do not overlap with those of the monoculture maize. The probability of Gliricidia-maize intercrop treatments being perceived by farmers as very good or "best" was significantly higher than that of monoculture maize.

Group voting

The group voting results (Table 5) showed that Gliricidia-maize without fertilizer amendment was the most prefer-

Table 5. Farmers' group voting on Gliricidia-maize options for increasing maize yield.

Treatments	Absolute counts (n = 68)	Preference (%)	Overall ranking
Gliricidia-maize without fertilizer	41	60	1
Gliricidia-maize + 50% RNF[†]	24	35	2
Gliricidia-maize +25% RNF	3	4	3
Monoculture maize + 50% RNF	0	0	4
Monoculture maize +25% RNF	0	0	4
Monoculture maize (un fertilized)	0	0	4
Total	68	100	

[†] RNF= Recommended Nitrogen Fertilizer dose (92 kg ha-^{1}).

red treatment by the majority of farmers (60%), followed by Gliricidia-maize amended with 50% of the recommended fertilizer doze (35%). The group ranking did not show clear distinction between the monoculture maize treatments.

Farmers assessment of rotational fallows

Overall, based on the mean rank order and total weighted order value the three top-performing treatments were *T. vogelii*, *sesban* and *G. sepium* (Tables 6 and 7). *T. vogelii* was ranked the best by 84% of the participating farmers compared. Apart from *S. sesban* which was ranked as the best by 26% of farmers, no other species was ranked best by more than 19% of respondents. More than 60% of farmers considered natural fallows and continuous cropping with or without fertilizers, *C. calothyrsus* and *T. diversifolia* as poor or very poor (Table 6).

The logit-linear model indicated significant difference between treatments (χ^2=574.2, df=13; P<0.0001) in farmers ranking of rotational fallows. The model gave 79.2% correct classification. The 95% confidence intervals (Table 7) indicated that farmers rank all the species except *A. americanum*, *A. herbertsmith* and *C. Calothyrsus* as significantly better than unfertilized monoculture maize, which was ranked the lowest. Similarly, the non-parametric test showed significant differences between treatments (P<0.0001) in the mean rank scores in Table 8.

Comparing the farmers who came for field days from four EPAs, Wilcoxcoxon's mean rank showed *T. vogelii, S. macrantha, S. sesban, G. sepium* and *T. candida* as the top five species (Table 8). All the four EPAs ranked *Tephrosia vogelii* as the best- performing agroforestry tree species. Unfertilized maize was the least ranked by all EPAs.

Farmers used a wide range of criteria for ranking the species that were used in the improved fallow trial. The ranking was based on the ability of the tree species to give adequate biomass rich in N that enhanced the following crop qualities: 1) vigor of the maize crop in the field, 2) height of the maize crop, 3) cob size, and 4) leaf color (greenness).

78% of the farmers who participated in the evaluation are currently using *T. vogelii* in their fields for soil fertility improvements, while 73% use *S. sesban* and 65% *Gliricidia*. Other species that farmers use in the field is *T. candida, S. macrantha, T. diversifolia and C. juncea* (22 - 35%) using them for 2 to 3 years.

The farmers were also asked to compare the performance of their agroforestry fields with those at the station. Results indicated that, there is generally low performance of these trees (48% of farmers' fields performed low) while 33% of the farmers' field performed the same as the on-station while 7.4% indicated better performance than the on-station trial (data not shown).

When farmers were asked to mention species or treatments they considered as unsuitable (Table 9), the following were named: continuous cropping of unfertilized maize (96%), unfertilized natural fallow (65%), continuous cropping of maize with fertilizer (26%) and natural fallow fertilized (22%). *G. sepium* was considered unsuitable for rotational fallows by 8% of farmers. In addition, 4% of farmers did not consider *S. sesban* as suitable.

DISCUSSION

There was strong concordance among farmers that Gliricidia-maize intercropping plots, with or without N fertilizer were superior to the monoculture maize. Farmer rating in this study also agrees with several studies involving Gliricidia-maize intercropping in Malawi, both on station (Akinnifesi et al, 2006) and on-farm (Harawa et al., 2006). Farmers believe that the coppicing ability of *G. sepium* enables them to obtain continued supply of green manure from a one-off tree establishment. The green manure improves nutrient supply to the crop thereby increasing yield for a long term.

The majority of farmers (71%) in the individual rating identified Gliricidia-maize intercropping amended with half of the recommended fertilizer dose as the best treatment. This suggests that farmers recognized the positive

Table 6. Relative assessment† of two-year rotational fallow species by farmers (n = 72).

Treatment	% Times ranked			Weighted count	Mean rank order	Overall Rank
	Very poor or poor	Fair or good	Very good			
Tephrosia vogelii	0.86	95.69	83.62	554	4.78	1
Gliricidia sepium	6.90	56.90	0.86	407	3.51	2
Sesbania sesban	20.69	63.79	25.86	401	3.46	3
Crotolaria juncea	24.14	43.10	0.00	389	3.35	4
Tephrosia candida	25.86	51.72	0.00	374	3.22	5
Sesbania macrantha	27.59	37.07	12.93	360	3.10	6
Aesynomene americana	28.45	28.45	0.00	323	2.80	7
Atelaria herbertsmith	41.38	17.24	16.38	294	2.53	8
Natural fallow (Unfertilized)	50.86	10.34	0.00	272	2.34	9
Calliandra calothysus	64.66	3.45	18.97	233	2.10	10
Continuous cropping (Fertilized)	6.38	.00	.00	215	1.85	11
Natural fallow (Unfertilized)	78.45	0.00	0.00	212	2.34	12
Tithonia diversifolia	75.00	2.59	8.62	208	1.79	13
Continuous Cropping (Fertilized)	87.07	0.86	0.00	169	1.46	14

†multiple choice permitted; ‡total weighted scores are calculated as ranking (weights from 1 to 5) multiplied by number of respondents; Mean order value is calculated as follows: if the treatment was mentioned as best or excellent it receives a value of 5, very good receives 4, good it receives 3, fair it receives 2 and poor it receives zero. The mean rank order is the mean of all values including zeros.

Table 7. Parameter estimates of the logistic regression analysis of farmers' assessment of the treatments in rotational fallows.

Parameter	Estimate	L95%	U95%CL	Chi-square	Probability
Intercept1 (Best)	-2.8	-3.0	-2.5	692.4	<.0001
Intercept2 (Good)	0.5	0.4	0.6	60.0	<.0001
Intercept3 (Poor)	--	--	--	--	--
Tephrosia vogelii	4.4	3.9	4.9	297.0	<.0001
Sesbania sesban	1.3	1.0	1.7	47.0	<.0001
Gliricidia sepium	1.2	0.8	1.6	37.7	<.0001
Tephrosia candida	0.9	0.5	1.3	21.9	<.0001
Crotalaria juncea	0.8	0.5	1.2	21.2	<.0001
Sesbania macrantha	0.6	0.2	0.9	9.6	0.0019
Aeschynomene americanum	0.4	0.0	0.7	3.6	0.0594
Atelaria herbertsmith	-0.3	-0.6	0.1	2.2	0.1344
Natural fallow (Fertilized)	-0.7	-1.0	-0.3	13.8	0.0002
Calliandra calothyrsus	-1.2	-1.6	-0.8	38.4	<.0001
Continuous cropping (fertilized)	-1.3	-1.7	-0.9	43.4	<.0001
Tithonia diversifolia	-1.7	-2.1	-1.3	62.9	<.0001
Natural fallow (Unfertilized)	-1.9	-2.3	-1.4	69.8	<.0001
Continuous cropping (unfertilized)	--	--	--	--	--

and synergistic effect of green manure from gliricidia and commercial fertilizer on crop yield. This observation has been confirmed by a long-term trial, which recorded a 30% increase in maize yield due to the synergy between green manure and fertilizer (Akinnifesi et al., 2006; Akinnifesi et al., 2007).

The results of the individual and group ranking of treatments slightly differed. For example, in the group voting,

Table 8. Relative assessment (mean rank scores) of rotational fallow species by farmers from four sites.

Treatments	Mean rank order value				Wilcoxon mean rank score
	Chiradzulu 1 (n= 49) †	Chiradzulu 2 (n= 24) ††	Malosa EPA (n = 19)	Thondwe EPA (n=24)	
Tephrosia vogelii	4.8	4.4	4.9	5.0	53.8
Sesbania macrantha	4.8	3.3	3.0	4.3	42.9
Sesbania sesban	2.1	4.3	4.3	4.6	40.6
Gliricidia sepium	3.3	3.3	3.6	4.0	40.1
Tephrosia candida	2.0	4.0	4.0	4.4	38.0
Aesynomene americana	2.9	3.1	3.1	3.6	35.1
Crotolaria juncea	2.3	3.0	3.0	3.8	31.8
Atelaria herbertsmith	1.8	2.8	3.1	4.2	30.1
Natural fallow (Fertilized)	2.2	2.5	2.3	2.5	22.3
Calliandra calothysus	1.4	2.2	2.6	2.5	18.6
Continuous maize (Fertilized)	1.4	2.3	2.0	2.3	14.9
Natural fallow (unfertilized)	1.6	2.2	1.7	2.3	13.3
Tithonia diversifolia	1.6	1.8	1.4	2.5	11.6
Continuous maize (unfertilized)	1.2	1.3	1.7	1.9	5.9

†Chiradzulu 1 (Farmers working with PROSCAP project);
††Chiradzulu 1(Farmers working with DAPP project).

Table 9. The most unsuitable soil fertility practice for improved fallows.

Practice	Counts	% Mentioned as unsuitable option
Sesbania macrantha	0	0
Tephrosia vogelii (mtutu)	0	0
Ateleria herbrtsmith	0	0
Crotolaria juncea	0	0
Tithonia diversifolia	0	0
Aesynomene Americana	0	0
Calliandra calothysus	0	0
Tephrosia candida	0	0
Sesbania sesban (Jere-jere)	1	4
Gliricidia sepium	2	8
Natural fallow (Fertilized)	5	22
Continuous cropping (Fertilized)	6	26
Natural fallow (unfertilized)	6	65
Continuous cropping (unfertilized)	23	96

farmers preferred Gliricidia-maize without fertilizer to Gliricidia-maize amended with 50% of the recommended fertilizer dose. This probably suggests that in the group voting the synergy effect of fertilizer may have been overridden by farmer's perception of the input requirements for each treatment. Despite the benefits in applying half the recommended N dose to the Gliricidia-maize plots, the maize yield increase was perceived to be relatively small compared to the high cost of the inorganic fertilizer. This is also a reflection of the lack of significant differences in the individual ranking of Gliricidia-maize treatments (Table 4). Farmers also mention that green manure is less damaging to the soils than inorganic fertilizers. Farmers often have complex criteria when considering diverse cropping systems, which include short-term food security issues, income generation, labour demands and long-term issues of soil fertility regeneration and resource conservation (Snap and Silim, 2002). This information may be important for policy discussions on the potential farmer acceptability of agroforestry with or without the fertilizer subsidy programme initiated in the past three years in Malawi. Farmers' preference and maize yield responses were more concordant with Gliricidia-based rather than inorganic fertilizer-based soil amendment practices.

A note of caution to the interpretation of this result is necessary considering that the study was conceptually based on a discrete-choice model. In a number of choices, farmers are expected to choose the "Best or very good" option based on optimization criteria. The absence of fully fertilized option as standard control may have influenced farmers' decision to consider fertilizer as superfluous in this case. Several on-farm and on-station trials have demonstrated that fully fertilized maize is superior to Gliricidia (Mafongoya et al., 2006; Akinnifesi et al., 2007). However, it is possible that farmers simply preferred to avoid any cost associated with the purchase of fertilizers if they can obtain near optimum with Gliricidia only.

Among the species used for rotational fallows, farmers ranked *T. vogelii*, *S. sesban* and *G. sepium* as the top most suitable species (Table 6). This was based on their judgment of the crop performance. However, the role of farmer's prior knowledge of the species cannot be ignored. Kuntashula and Mafongoya (2005) observed that most farmers who participated in technology assessment in Zambia had planted those species that they rated very high. Forty-eight percent of the farmers had previously seen *S. sesban* and *T. vogelii* through extension field assistants and 40% had known *G. sepium* before. Thirty-three percent of the farmers indicated that they knew *T. vogelii* from their parents since it locally occurs in their locations. Farmer's believe *T. vogelii* is the most suitable because (1) it is easy to establish by direct sowing, (2) it destroys witch weed (*Striga asiatica*) and makes maize grow fast, and (3) it is also used for treating scabies. Farmers' ranking of the top three species is in agreement with earlier research that has identified *S. sesban* superior for improved fallows (Kwesiga et al., 2003) and Gliricidia for intercropping system (Akinnifesi et al., 2007).

The ranking of continuous maize cropping without fertilizer as the least was not surprising as the soils in Malawi are low in nitrogen and grain yield in unfertilized field are very low (less than one tone per hectare). The assessment of *T. diversifolia* and *C. calothyrsus* as the least performing treatments was also not surprising. Visual observation of the crop and actual grain yield in the field (data not shown) supported farmers' judgment. However, for *T. diversifolia,* such performance did not confirm the superior on-farm performance of maize earlier reported elsewhere. Since *T. diversifolia* is a non-legume, its contribution is mainly phosphorus; therefore its performance may not be significant on sites where P is not limiting. Other studies have shown that P was not limiting at the Makoka site (Akinnifesi et al., 2006).

The fact that majority of farmers (96%) had rated continuous cropping without fertilizer as highly unsuitable, probably because farmers often operate at a loss when fertilizer is not used. In addition, 26% of farmers rated continuous cropping with fertilizer as low. This was attributed to the high cost involved fertilized plots and marginal increase when less than optimal rates are used compared to unfertilized plots. Most farmers apply less than 30% of recommended fertilizer rates in Malawi (Snapp et al., 2002). Natural fallow without fertilizer was ranked as second unsuitable treatment by 65% of the farmers indicating inefficiency of natural fallows for soil fertility regeneration in these low fertility soils. Application of fertilizer to maize cropped either in rotation with the natural fallow or continuous monoculture was considered unsuitable probably because the soil organic matter is generally low under such systems, and returns are low.

Some farmers reported poor performance of species on their farms than on-station. These farmers indicated that the technologies performed poorly on their fields because: (1) the farmers have only used the trees for less than two years; (2) they did not follow the recommended management of the technologies, (3) tree establishment problems resulted in inadequate biomass availability; and (4) the planting of too many crops in the same field and there by increasing the completion among the crops. It is not surprising that some farmers indicated low biomass production of improved fallows in some sites as reason for poor performance. In such situation the biomass produced by fallows could be constrained by low soil fertility and a supplemention with micro dozes of inorganic fertilizers, especially P is worthwhile (Akinnifesi et al., 2007).

The farmer participatory evaluation used in this study has several advantages primarily because the activity of ranking the technology can be conducted while farmers are learning other aspects of agroforestry technologies in the form of the field days (spill-over effect) and therefore, they are less costly in time and resources. The second advantage of this method is that it provides information from farmers at an early stage of technology development compared to on-farm trials, given that research programmes usually require new materials to be tested on-station before they are introduced on-farm (Franzel et al., 1995). Thirdly, it facilitates direct interaction between the researchers and farmers, in contrast to surveys and on-farm trials which often provides feedback only to those who conduct them. On the other hand, the evaluations have some serious weaknesses; the information is likely to be of lower quality than in surveys and on-farm trials, where the farmers have the opportunity to continuously evaluate performance of the agroforestry technologies on their own farms.

One of the insights gained from this study is that farmers' assessments of technologies have the potential to improve the relevance of on-station researcher-designed trials. Researchers face challenges in designing cropping systems that meet farmer preferences when high performance is considered as the only incentive to cultivation. Given this situation, a farmer requires a wide range of options that can meet diverse needs for short-term as well as long-term goals, including providing enough food for consumption and market. This work shows how farmers can help researchers in technology validation processes.

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