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Farmer assessment of selected shrub species for improved fallow technology in Mukono district

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Abstract

Four nitrogen fixing species were planted as short term fallows on poorly yielding soils in Nagojje and Najjembe sub counties of Mukono district. These were *Crotalaria grahamiana, Tephrosia vogelli, Sesbania sesban and Cajanus cajan.* Then a post fallow crop of beans or maize was planted together with a control. Crotalaria and Tephrosia flowered and attained maximum biomass within one season (six months) while Sesbania and Cajanus flowered after two seasons (twelve months). Post fallow crop yields were high for all fallow species compared to the control. In beans Crotalaria was highest followed by Tephrosia and then Sesbania. In maize Crotalaria and Tephrosia performed equally well and better than Sesbania. Therefore Cotalaria and Tephrosia are promising as shrubs that can be adapted for short term improved fallow in Mukono district.

Introduction

Low soil fertility on smallholder farms is a fundamental cause of food shortage in sub-Saharan Africa. These soils have become so depleted of nutrients that they don't produce enough food that can support the growing populations.

The most conventional way to improve soil fertility is to buy inorganic fertilizers to provide nitrogen(N), phosphorus(P), and potassium(K). Unfortunately they are no longer an option for the majority of African subsistence farmers for they cannot afford them. And yet it is these subsistence farmers who grow most of Africa's food. This then poses a question of what to be done to ease the soil fertility crisis and be able to restore and rejuvenate the soil fertility status. If this situation goes unchecked, this automatically causes a reduction in per capita food production

In central Uganda, for example, there has been a decline in production of maize. The region was at one time a major banana producer recording over 40t/ha which has been reduced to a mere 0.8t/ha. Low soil fertility is the fundamental biophysical cause of this declining production. Nutrient balance studies in central Uganda show minimum use of external fertilizer inputs, which results in net nutrient losses and renders the farming system unsustainable (Wortman and Kaizzi,1997). Nitrogen is the most affected with studies showing about 94ha/yr of the nutrient being mined through crop harvest under a maize crop system.

In areas near natural forests, such as Mabira, poor fertility on the existing cropland has been cited as one of the main causes of degradation of these forests as farmers seek fresh land for crop production. Sustainable options to replenish the declining fertility need to be developed. This may go a long way in increasing production per unit area and hence protect the Mabira forest from further farming related degradation. However, a choice of a soil management practice to improve soil fertility is of utmost importance both agronomically and economically. Farmers can choose from the following; chemical inorganic fertilizers, green manure, compost, natural fallows or improved fallows.

Chemical fertilizers do quickly offset nutrient shortage but their availability and costs limit their use on smallholder farms as evidenced by the low use of commercial fertilizers in Uganda (Bekunda and Woomer,1996). Green manure and compost require large quantities of biomass which most farmers cannot easily access. Natural fallows on the other hand take two to three years, a period which farmers with small land holdings find too long to wait.

Use of improved fallows would be another practical and cheap option for the resource poor farmers. Improved fallows involve the planting of nitrogen fixing leguminous shrubs on poor soils which are cut after a season or two when they have attained maximum biomass. Then they are allowed to shed their leaves which together with roots are dug and incorporated into the soil.

High quality leguminous materials are known to quickly release plant nutrients particularly nitrogen, while offsetting soil organic matter losses and subsequently improve physical properties of soils. The most peculiar and important aspect in the use of shrubs to replenish soil is that farmers can multiply their own seed for further fallowing, making the system sustainable.

A range of short -term leguminous tree species have been tested for fertility replenishment in neighbouring western Kenya, whose agro-ecological conditions do not differ much with those of the lake-shore area of central Uganda. Both on-station and on farm research shows that over two to three season leguminous tree fallows, using species such as Sesbania sesban, Crotalaria grahamiana, Tephrosia vogelii rotation with maize, can accumulate from the air 100 to 150kgs of nitrogen per hectare- an amount sufficient for 2-3 extra tones of maize grain yield.

In western Kenya maize yields were 70-80% higher after one season fallow of Sesbania sesban and Tephrosia vogelii (Niang et al, 1998).

Following the ICRAF flagship model, the apparent overall objective of this activity therefore is to adapt, in the Mabira buffer zone areas, these short–term leguminous shrubs already tested and proven to be effective and being promoted in western Kenya for soil fertility improvement.

The approach used in this particular case does not emphasize qualitative testing of these shrubs, but rather focuses on their adoption and performance in the Mabira buffer zone situation. It may later be possible to go in depth to investigate the soil status as the technology shows potential positive diffusion.

Broad objective

To adapt short term leguminous shrubs for soil fertility improvement in Mabira buffer zone.

The specific objectives

1 To assess species performance in terms of biomass i.e. amount of leaf, twig and woody material.
2 Establish duration from planting to flowering in order to identify species that fit well into local seasons
3 Establish differences in crop yields between different species after the fallow

Materials and Methods

Selection of farmers

An informal discussion was held with farmers from the Mabira forest buffer zone (Nagojje and Najjembe sub counties) on general crop production constraints. Over 70% of the farmers attributed the low crop harvests to depleted soils. Some parts of Mabira especially in the forest enclaves like Kyajja in Nagojje were thought to be still fertile, vermint like monkeys and wild pigs were cited as their biggest problem. From the survey 25 farmers with obvious soil fertility problems in Najjembe(19) and Nagojje (6) sub-counties of Mukono district were identified to start on improved fallows. Farmer's willingness to plant soil-improving trees and monitor their performance was among the key criteria for farmer selection. Looking at the number of the experimental farmers, it is easy to notice that there was a clear understanding of soil fertility issues in Najjembe than in Nagojje sub-county thus the reason for easy will and mobilization. This is true given the situation that most settlements in Nagojje sub-county are in forest enclaves with no fertility problem hence less willingness to try the technology. In Najjembe, the situation is seen to be overdue for intervention and is being taken up with its deemed necessity.

Training

Farmers training sessions were conducted in the field in their respective villages. This involved a review of the performance of the short-term fallow trees elsewhere particularly in Western Kenya, clearly spelling out the objectives of this farmer managed experimentation and the role of farmers and researchers in this work. It also involved discussing and agreeing on the site conditions and the design of the experiment with farmers. It is at this point that tree-planting demonstrations were carried out and site visits made having agreed that farmers choose the worst performing parts of their fields where it is easy to notice a significant change or difference after the fallow period.

Experimental design and treatments

Seed of the following short-term leguminous tree shrubs was supplied to farmers except for Sesbania which was supplied as bare-rooted seedlings:

1. *Crotalaria grahamiana,*	400gms
2. *Tephrosi vogelii,*	400gms
3. *Tephrosia candida*	400gms
4. *Cajanus cajan*	500gms
5. *Sesbania sesban*	700 seedlings

Due to small land holdings, most farmers could not plant all the five tree species on their farms but were required to establish at least two tree species and reserve a control plot (continuous cropping or natural fallow) for comparison purposes.

Farmer's choice of the trees to plant depended so much on the information from the training sessions. The majority of the farmers had four treatments namely: Crotalaria grahamiana, Tephrosia vogelli, Sesbania sesban and the control.

Each treatment was in a plot of minimum dimension of 10mx10m,separated from each other by at least a 1m strip although most farmers however had much bigger plots. A tree spacing of 50cmx50cm was recommended but in practice it varied widely among farmers . This depended so much on the crop in which the tree shrubs were being integrated. Within a maize field, tree cover crops were planted between rows of maize (60cm x 50cm) while in the beans they were planted at 50cm x 50cm. Each farmer is regarded as a replicate and the trial as a randomized design.

Tree management regimes

Trees were planted by farmers in mid-September 2000 at the start of the rainy season. In all cases the fields were properly cultivated and planted with either beans or maize. After two weeks farmers planted seed of Crotalaria, Tephrosia and Cajanus between the rows. Sesbania seedlings were also transplanted at the same time. This was done in order to avoid shading of crops by trees.

After crop harvest, trees were allowed to continue growing for maximum biomass production. Weeding of trees was done at the same time with crops but when they were left as sole stands after crop harvest it was not necessary in order to leave the field as a fallow.

At the start of the rainy season (March-April 2001) farmers cut down the tree shrubs and left them in the field for one week to drop their leaves while the woody materials were removed for firewood. The cutting was done for all shrubs at the same time based on the shrub that flowered and attained maximum biomass first. The leaves, twigs and roots were dug in to incorporate them into the soil for fertility replenishment. Planting of the crop (beans or maize) took place a week after digging in order to allow for adequate decomposition.

Observations

1. Species performance in terms of biomass i.e. amount of leaf, twig and woody material.
2. Duration from planting to flowering
3. Differences in crop yields between different species after the fallow

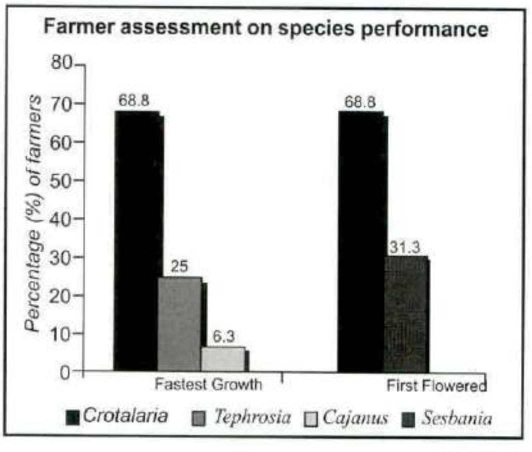
Results

During August 2001, a sample composed of 16 farmers was interviewed in order to capture farmers perception on the improved fallows. The survey produced the following results:

Fig. 1 shows that of the 4 species planted, *Crotalaria* grew fastest followed by *Tephrosia* and then *Cajanus*. *Sesbania* was the poorest. Growth was assessed by looking at height and crown width. *Cajanus* and *Sesbania* shrubs grew mostly upright with a single stem without a lot of leafy biomass while *Crotalaria* and *Tephrosia* branched a lot and formed wide crowns and a lot of leafy biomass. Poor growth in *Sesbania* could be partly attributed to shock suffered at transplanting because it was planted as bare root seedlings. In addition farmers did not time the rains correctly and so seedlings suffered water stress.

68.8% of farmers observed that *Crotalaria* flowered first while 31.3% mentioned Tephrosia. *Cajanus* and *Sesbania* did not flower during the first six months.

Figure 1. Farmer assessments on species performance



Vigour was observed as greenness, shoot development and overall healthy appearance of the crop. In terms of crop vigour after fallow, 56.3% of the respondents rated *Crotalaria* as giving good to excellent results while 37.6% recommended *Tephrosia*. *Sesbania* was scored as fair by 18.8% while natural fallow was 6.3% (Fig.3). On the overall, both crops (maize and beans) performed best under *Crotalaria* and *Tephrosia* followed by *Sesbania* and the natural fallow was least.

Farmers indicated yields based on the 10mx10m plots. Crotalaria and Tephrosia gave the highest maize yields of about 33 kg per plot each, Sesbania plots yielded about 20 kg and the natural fallow plots yielded about 7 kg.

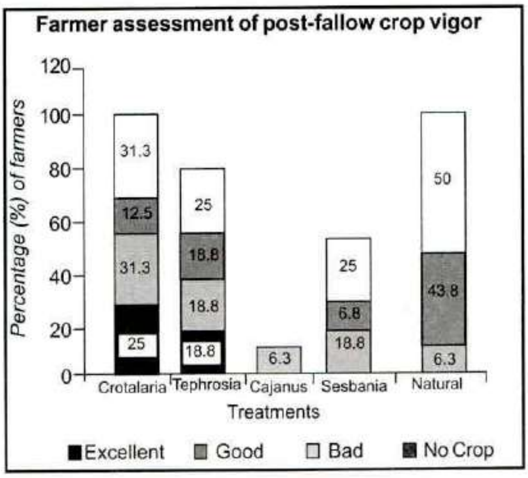


Fig.2 Farmer assessments of post-fallow crop vigor

With beans Crotalaria plots yielded about 33 kg, Tephrosia gave 25 kg, Sesbania 17kg while the natural fallow plots yielded 6 kg.(Fig.3).

The Sesbania fallow did not vary greatly from natural fallow because it was cut very early during growth before attaining required biomass. In addition, there had been poor establishment.

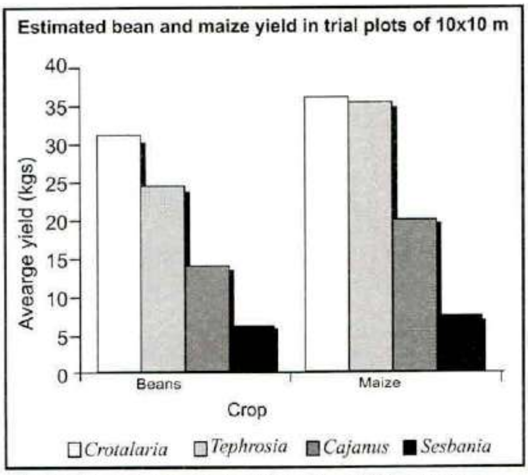


Fig 3: Farmer assessments of post-fallow crop yields

Discussion and Conclusion

Based on this experimentation, it has become clear that *Crotalaria grahamiana* and *Tephrosia vogelii,* stand a potential candidature for use as leguminous shrubs for improved fallow in this study area for soil fertility replenishment. This is because they have shown higher chance of easy establishment, vigour and attainment of maximum biomass within 5-6 months. This is fitting within timing of the local rainy seasons in the area. It appears *Sesbania sesban* and *Cajanus* cajan need more time (11-12 months) to attain the recommended biomass, making then fit into a two season fallow. This period is rather long as farmer may be having no where else to cultivate and losses patience.

Crotalaria and *Tephrosia* treatments have resulted in increased yields for both maize and beans as compared with a natural fallow. However, farmers registered less yields in *Tephrosia* than *Crotalaria*. This is attributed to differences in attainment of maximum biomass between the two species as *Crotalaria* flowered before Tephrosia and yet were cut at the same time. Yields from *Sesbania* fallow were as low as from the natural fallow. This is associated with the early cutting of the shrub before it attained maximum biomass.

More research is needed to compare post fallow crop yields of *Crotalaria* and *Tephrosia* when each of them is cut after attaining maximum biomass. In addition it is necessary to establish how long the post fallow residual effects last for each of the selected species.

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Suitable species and provenaces for plantation forestry in Uganda

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Abstract

This paper reviews past experience in identifying species and provenances for plantation forestry. Research to select suitable species and provenances for planting in Uganda started in 1908 and 1966 respectively. The review, however, emphasizes the period after 1953 when the first silvicultural research plan was written. Since then more than 170 species have been tried in about 400 research plots located in every agro-ecological zone. Among the exotic gymnosperms, *Pinus caribaea, Pinus oocarpa* and *Pinus patula* are by far the most suitable for timber production in the country. *Araucaria angustifolia, Araucaria hunsteinii, Araucaria cunninghamii* and *Cupressus lusitanica* are also important plantation species. Eucalyptus species; *Eucalyptus grandis, Eucalyptus camaldulensis* and *Eucalyptus tereticornis* performed best among the angiosperms. *Terminalia, Markhamia, Measopsis* and *Cordia* species have also performed satisfactorily. The single most serious drawback to the success of plantation forestry in Uganda has been lack of strong tree improvement programme to consolidate and sustain the remarkable gains thus far made.

Introduction

As early as 1900, the natural forest estate in Uganda was considered to be inadequate for sustainable supply of wood products and services. Thus, by 1908 some hardwood plantations had been established around government stations. These consisted of prime indigenous timber species; Melicia *excelsa* (mvule); Entandrophragma utile, *E. cylindricum*, E. *angolense*, and *Khaya anthotheca* (mahoganies); Markhamia lutea (nsambya), Measopsis *eminii* (musizi). But these species generally grew too slowly to meet the anticipated increased demand for wood and wood products. Tree species that could grow rapidly and had other desirable characteristics had to be identified for plantation forestry.

But the choice of species is an important decision in tree establishment. First, the species to be planted should be adapted to the site, climate, soil and the abiotic environment. Usually, suitable species and provenances show superiority in survival, growth, form and utility. Species and provenance research is a very important approach in meeting this challenge. It ensures that plantation forestry is carefully planned and given a proper position in the overall national landuse.

It is however important to point out that the suitability of a species cannot be judged on the basis of one provenance only. A species trial therefore has to include several promising provenances.

Analysis and comparison between the site conditions of the countries involved and the ecological characters of the different provenances is basic to species and provenance trials.

Species and provenance trials

Species trials in Uganda are as old as tree planting itself which were generally carried out by District Forest Officers and Local Authority staff (Anon. 1951). Intensive research on the species began after 1953 when methods of research planning and recording were established in the first silvicultural research plan (Kriek, 1970). Records indicate that over 42 pine, 11 cypress and 52 eucalyptus species, many of which originated from S. Africa where they had been successfully cultivated for over 70 years, were evaluated within the decade following the upsurge. Three basic parameters; survivorship, growth rate and stem form were investigated in these trials.

In 1966, the East Africa Agricultural and Forestry Research Organization (EAAFRO) initiated provenance research mainly on *P. patula, P.oocarpa, P.caribaea, C. lusitanica* and eucalypts which earlier on had been identified for plantation development in Uganda. Tree seed for these trials were obtained from local and foreign sources. Research plots were located on the basis of the objective of the subject to be studied. Traits assessed included percent survival, total height, diameter at breast height (dbh) over bark, stem straightness (an index based on an assessment of straightness in 1-m sections of the first 6m of the stem), stem lean, and multiple stems. Other secondary parameters considered include branching habit and crown depth.

Plantantion species identified

Throughout the trials, care was taken during planting to give the plants under trial opportunity to show their true response to site factors. Periodic assessment and data collection were done according to experimental plans using specific forms. ANOVA (Steel and Torrie, 1980) was carried on the diameter and height measurements to Other parameters considered include; branching habit(s), crown depth and the shapes of the stems/ bolesdetermine their significance Plantation species identified.

Following the analysis of data on tree diameters and heights, major species for plantation development in Uganda were identified. Five conifer species were selected for planting in both highland and lowland reserves. *Pinus patula, Pinus radiata* and *Cupressus lusitanica* were earmarked for the highlands (>1200m asl). *Pinus caribaea* and *Pinus oocarpa* were designated for the low-lying reserves (<1200m asl). Araucarias, *A. cunninghamii* and *A.hunsteinii* have performed best on cleared forest sites in the lakeshore region. Other pine species which have shown good performance but are rarely grown on plantation scale include *Pinus kesiya, P.strobus, P.douglasiana*, and *P.leiophylla*.

Out of the 52 species of eucalyptus tried, only 3 species, E. grandis (saligna frequently hybridises with grandis), E. camaldulensis and E. tereticornis were selected as the major plantation species. Unlike the conifers, the general populace of Uganda also readily took the planting of eucalyptus. So that in the highlands of western Uganda, where termites are not problematic, *Eucalyptus grandis* is privately grown very extensively on small holdings. *Eucalyptus tereticornis* and *Eucalyptus camaldulensis* on the other hand are the major species grown in the drier parts of the country.

Discussion

Successful species and provenance selections is normally reinforced with a strong tree improvement programme. However, for Uganda no basic tree improvement has been attempted ever since plantation species were selected in the early fifties. Thus technically, Uganda has for over half a century been using inferior germplasm in her plantation forestry. The situation was exacerbated by total breakdown of law and order in the country during which no silvicultural operations were carried out in most plantations. The current crop of exotic conifers being exploited bears the scar of this period. Unfortunately, the bulk of the national planting materials are yet derived from these unimproved sources.

Notwithstanding however, eucalypts have been taken up by the private farmers due to their heavy seeding character, fast growth rate, relatively straight stems coupled with their ability to coppice regardless of the season of harvest. Nevertheless, cultivation of eucalypts is constrained by two major factors, namely, lack of quality seeds and poor nursery techniques. Flowering in eucalypts is synchronous, because of this behaviour eucalyptus species hybridize among themselves. Seeds obtained from the local sources are therefore permanently contaminated through natural hybridization. Thus, there are no known pure stands of eucalypts in Uganda. Although some first generation hybrids are superior to either parent species, F2 and subsequent generations show classic segregation and hybrid breakdown.

Fortunately new cloning technology developed by Mondi forests of South Africa, has overcome the hybridisation problem. This technology makes it possible to mass produce superior planting materials within a short time. FORRI together with her collaborators from South Africa, United Kingdom and Kenya is introducing this technology to Uganda. The development of clonal forestry will not only help in preserving superior genetic material but also in shortening the maturation period. Furthermore, it is easy to match clones to sites more precisely than otherwise. The greatest advantage of clonal forestry is its ability to produce wood which is tailored to meet very specific requirements e.g. pulp, lumber, poles or wood based panels.

Currently other hardwood species which have demonstrated good performance are rarely used in plantation forestry. And yet these species exhibit rapid growth and when combined with proper silvicultural treatments (spacing, thinning and pruning) can give good productivity (Tables 1 and 2), hence potential for higher financial returns given that natural forests of Uganda are incapable of attaining annual increment of $1.14m^3ha^{-1}$ (Dawkins, 1959).

The inability of natural forests of Uganda to produce enough wood will become apparent when the demand for industrial wood (pulp and paper) begins to compete with the conventional demand for roundwood (sawlogs and firewood). Many species in our natural forests will produce some firewood and usable building poles but their defects will become obvious when attempts will be made to convert them into sawn lumber, pulp and paper, fibreboard, particleboard or wood based panels.

Table 1:Yield in m³ ha⁻¹ of selected 25 year old gymnosperm and angiosperm species at various sites (Source: Research Files, FORRI archives)

Species	Mafuga	Bugamba	Katugo	Kifu	Kanyawara	Lendu	Kapkwata	Oruha
P. oocarpa		**360**	**362**		**470**			
P.caribaea		**580**	**330**		**450**	**700**	**344**	**550**
P. patula		**450**	**230**		**350**	**670**	**594**	**350**
P. radiata		**160**	**180**		**280**			
C. lusitanica		**500**			**260**	**490**	**517**	**250**
Araucaria hunsteinii				**1380**				
A. angustifolia			**927**					
Terminalia superba			**1752**					
T. ivorensis			**779**					

Table 2: Mean annual height increment (m) of selected Eucalyptus species at various sites (Source: Research Files, FORRI archives)

Species	**Fort Portal**	**Mbale**	**Kajjansi**	**Nagojje**	**Arua**	**Iganga**	**Kumi**	**Karamoja**
E. grandis	4.6	2.5	4.3	6	2.5			
E. camaldulensis							2	2.3
E. tereticornis					3.8		1.4	3

Conclusions and recommendations

The number of tree species currently being utilized in Uganda are too few. Therefore there is adequate room for additional species and provenances to be tried and introduced, particularly in north-eastern and other arid (cattle corridor) parts of the country where population pressure is not yet acute. Similarly, there is a need to initiate a strong tree improvement programme to ensure qualities of the germplasms. In all these endeavors entomological and pathological studies should be incorporated from the outset to avoid future pest and disease problems.

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