

Mixed species improved fallows for Western Kenya

Declining or low maize yields on smallholder farms are common in Western Kenya particularly since fertilizer prices have increased and the associated nutrient mining has decreased soil fertility. Natural fallows, which normally consist of a combination of broad-leafed weeds and grasses, are used to restore soil fertility or to provide fodder for livestock but their effectiveness is low. Recent results have shown that improved fallow systems with fast-growing tree or shrub legume species like *Sesbania sesban* have a high potential to restore soil fertility and have become a central agroforestry technology for soil fertility management. These technologies have proven a high adoption potential with smallholding farmers in western Kenya and southern Africa. *Sesbania* has been the main focus for this technology partly due to its long traditional history with farmers and for its compatibility with crops, deep rooting, supply of additional wood products and large benefit to maize planted after the fallow. More recently other species such as *Crotalaria grahamiana* and *Tephrosia vogelii* have been tested with success in the region.

Benefits from improved leguminous fallows

Short duration improved fallows of 6-12 months increase the yield of subsequent maize crops by 1-3 t/ha in the first season compared with continuous maize cropping or natural weed fallows with subsequently lower benefits in year 2 and 3. The processes by which improved fallows achieve these benefits are by:

a) Accumulation of large amount of nitrogen rich biomass which is easily decomposable and hence releases nutrients rapidly into the soil, b) improved soil organic matter and soil structure (noted by easier tillage operations), reduced erosion and improved weed suppression in dense fallows such as *Crotalaria grahamiana*, c) *sesbania* fallows have a very deep root system and thereby effectively capture mineral nitrogen which has been leached below the crop rooting zone. This leads to a better recycling of nitrogen and reducing nutrient losses, d) leguminous fallows additionally enrich soil fertility through the process of biological nitrogen fixation (BNF). In this process the plant forms a symbiosis with a soil bacteria called *Rhizobium* which is able to transform nitrogen from the air into ammonium which the plant can assimilate. Plants who are effectively fixing nitrogen can be identified by the appearance of nodules on their roots (Figure 1). Actively fixing nodules have a pinkish interior color. The inputs from BNF and deep soil nitrogen capture provide sufficient N for the subsequent maize crop without necessitating N fertilizer additions.



Table 1: Biological Nitrogen Fixation (BNF) by fallow species in Western Kenya:

Species	Recyclable N 9 month fallow (kg N/ha)	Proportion of N derived from BNF (%)	Amount of N fixed (kg N/ha)	
			8 month old fallow ¹	12-15 month old fallow
<i>Crotalaria grahamiana</i>	150	67-80	150	90-220
<i>Sesbania sesban</i>	60	49-65	70	60-120
<i>Cajanus cajan</i>	110	57-72	110	110-170
<i>Tephrosia vogelii</i>	120	58-73	110	-

1) optimum growth conditions on farmers field

Why mixed species fallows ?

Improved single species fallows might fail due to adverse weather conditions (drought, logging) or establishment failure (poor seed quality or lack of proper seed pre-treatment). Some fallow species are less effective in capturing subsoil nutrient or nitrogen fixation than others. The introduction of new species to the area has led also to the build up of new pests e.g. caterpillar attacks on *Crotalaria grahamiana* are now more often observed. On the other hand recent evidence suggested that the indigenous *Sesbania sesban* together with *Tephrosia vogelii* is a host for root-knot nematodes (that are nodule like but are not easily rubbed off) which affect also common beans and hence it is recommended not to plant beans in the first season after these fallows. Thus increasing the biodiversity of the system by using mixed species fallows is essential to ensure sustainability of the production system.

Advantages of mixed species fallows

Insurance against fallow failure due to adverse weather conditions (drought, logging), pest attacks or establishment failure. The more resistant species will at least partially compensate for the low yield or failure of the susceptible species.

Multiple use of byproducts: *Sesbania* fallows produces a large proportion of wood (80% of biomass) which is very much appreciated by farmers which are deprived of firewood. However, the partitioning of resources into wood leads to a lower amount of foliage returned to the soil and leads to export of fixed nitrogen from the plot (30%). Mixing *sesbania* with *crotalaria* ensures both the benefit of wood as well as a large production of foliage biomass.

Improved utilization of available resources: The tall *sesbania* with an open canopy mixes well with the lower but dense growing *crotalaria* (Figure 2). This potentially also leads to a better light utilization. Mixing the deep rooted *sesbania* with *crotalaria* led also to a better subsoil mineral nitrogen exploration.

Maximization of fallow yields: Yields do not necessarily increase under non-stress conditions. However, where siratro was undersown under sesbania, cajanus and tephrosia larger yields were observed.

Prolonged residual effect: Mixing species of different leaf qualities and decomposition rates may reduce nitrogen losses and extend the time of residual effect.

Reduced pest pressure: Reduced insect attacks have been reported in mixed compared to single species fallows but further investigations and testing by farmers are needed.

Recommended species combinations

1. For recycling of deep soil N, high inputs from biological nitrogen fixation and a wood component:

Sesbania sesban + *Crotalaria grahamiana* (Figure 2)



2. To maximise fallow

biomass production or to provide a fodder (siratro, up to 2 t/ha in 6 months) component:

Sesbania sesban + *Macroptilium atropurpureum* (siratro) (Fig.3)

3. For producing a food crop during the fallow period:

Sesbania sesban + groundnut

Cajanus cajan + groundnut

As sesbania and cajanus have an open canopy during the early establishment a short duration groundnut variety can be planted in between the sesbania rows during the short rains (groundnut yield is about half of pure groundnut stands).

4. Other successful combinations: *Sesbania* + *Tephrosia vogelii*



Farmers are however encouraged to test other combination for their suitability for their particular needs. To ensure optimal use of the fallow the subsequent maize should be fertilized with 50 kg P/ha and 50 kg K/ha as most soils of Western Kenya are strongly P deficient and some are K deficient.

Management of mixed species fallows

Optimum management is important for a successful mixed species combination. Particularly the sowing time is crucial as otherwise strong competition from the faster establishing species suppresses the development of the other slower species. Recommended sowing times are:

Sesbania sesban: at maize planting (due to slow establishment) during the long rains in the maize row (spacing 75 cm).

Sesbania seeds need to be scarified by soaking them in warm but not boiling water overnight.

Crotalaria grahamiana, *Tephrosia vogelii*, *Cajanus cajan*: after second weeding during the long rains in maize row row (spacing 75 cm). No seed pre-treatment is required.

Macroptilium atropurpureum: at second weeding broadcasting. Siratro seeds need to be scarified on sand paper.

Benefits of mixed species fallows

Recommended minimum duration is about 9 months with larger yield benefits obtained for longer duration fallows. The costs of fallow establishment and loss of a maize crop are offset by the increased grain yield after the fallow, reduced labor and potential savings in N fertilizer.

Table 2: Increase in maize grain yield over yield of continuous maize control following improved fallows in Western Kenya. (values in brackets are benefits in 2-4th crop after fallow).

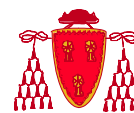
Species	Byproduct	Increase in maize grain yield (t/ha)		Economic benefit ¹ KSh/ ha/3 seasons
		6-9 month fallow	12-15 month fallow	
Sesbania + Crotalaria	Wood 4-10 t/ha	1-2 t/ha (0.5-1)	2-5 t/ha (1-2 t/ha)	15000
Sesbania + siratro	Fodder 1-4 t/ha	1-2 t/ha (0.5-1)	2-5 t/ha (1-2 t/ha)	20000
Sesbania + groundnut	Groundnut 0.2 t/ha	1-2 t/ha (0.5-1)	2-5 t/ha (1-2 t/ha)	23000


1 of a 6-9 month fallow above continuous maize cropping

These recommendations derived from a DFID (Natural Resources Systems Programme, project No. R7056)/EU (Pilot project) funded project. However, DFID accepts no responsibility for any information or views expressed.



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