Alley farming and protein banks for tropical Africa

by O. B. Smith

INTRODUCTION

The main traditional land use system for food production in tropical humid Africa is the shifting cultivation-bush fallow system. Long fallow periods, ranging from 5-10 or more years, depending on the crops cultivated and available land, were the normal practice. With such long fallow periods, full vegetation regeneration and soil fertility restoration were possible and the system was ecologically balanced and sustainable.

With rapid population growth and increasing demands for food and other competing land uses, fallow periods are continually being reduced, with a resultant decline in soil fertitility and productivity. In addition, a greater area of cultivated land has been used in response to the increased requirements for crops.

Both the reduction in the fallow period and the expansion of cultivated land have resulted in an ecological imbalance and land degradation which, according to FAO (1982), are responsible for excessive "savannization" and "grassification" in the sub-humid zones. Efforts are therefore being made to develop more sustainable and productive land use systems to restore and maintain the ecological balance and soil fertility on a long-term basis.

Agroforestry techniques which involve intercropping of leguminous or non-leguminous trees and shrub species with food and forage crops have been particularly exploited for this purpose. Alley cropping for food crop production and alley farming for both crop and animal production are two such agroforestry technologies.

In the drier savannah zones, three types of farmers are in competition for a limited and dwindling land resource: the pastoralists who migrate in and out of the zone and therefore appear to have unlimited grazing, albeit of poor quality; the cultivators who are not only expanding their cultivated areas but are also degrading the land through reduced fallow periods; and the agro-pastoralists who have limited grazing resources for their large livestock herds. The last of these (agropastoralists) have no tradition of fodder cultivation and their livestock therefore suffer from qualitative as well as quantitative feed shortages, particularly during the long dry season, with resultant weight loss and poor productivity. The fodder bank concept was developed to alleviate this constraint and improve livestock performance.

DEFINITIONS

Alley cropping

According to Kang *et al.* (1984), alley cropping (also known as hedgerow intercropping or avenue cropping) is an agroforestry system in which food crops are grown in alleys formed by hedgerows of trees and shrubs, preferably legumes. The hedgerows are cut back at planting and periodically pruned during cropping to prevent shading and to reduce competition with the associated food crops, but allowed to grow freely to cover the land when there are no crops. The system has been described as an improved bush-fallow system, as it retains the basic features of the latter but is improved in the sense that the cropping and fallow phases take place at the same time and on the same land, thus allowing more intensive cropping for a longer period of time. A summary of other differences is shown in Table 1.

Alley farming

The alley cropping system extended to include livestock by feeding a portion of the hedgerow foliage to animals was described as alley farming by Okali and Sumberg (1985). Both systems are similar, except that hedgerow management differs when the purpose includes animal feed production. Alley farming in its purest form essentially promotes crop-livestock integration and the production of a mulch for improved crop production is still one of its objectives. In alley farming most of the hedgerow foliage is used as mulch during the wet, crop growing season, particularly during the early growth phase, while a higher amount goes for animal feed during the dry fallow period. Thus foliage pruning must be strategically managed to satisfy both requirements.

A field data-based model developed by Sumberg *et al.* (1985) adequately demonstrates the crop-livestock integrating purpose of alley farming. The authors reported that about 80 kg mulch nitrogen would be required to maintain a base maize yield of 2t/ha, decreasing annually by 20% because of soil infertility. A one hectare alley farm producing 6 tons dry matter of foliage would supply this with 2.8 tons of dry foliage at 2.9% N. The surplus 3.2 tons would be sufficient to supplement 29 goats for one year, at the rate of 300g of foliage /day.

TABLE 1. **Differences in management between traditional bush fallow and the alley cropping system.**

BUSH FALLOW	ALLEY CROPPING
- Mixed native woody species	- Selected woody legumes
- Irregular planting pattern	- Planted in hedgerows
- Trees and shrubs cut back and burned before cropping to release nutrients	- Periodic pruning of trees and shrubs for use as mulch and green manure
- Growth controlled by fire	- Periodic hedgerow pruning
- Allows short-term cropping following fallow	- Allows continuous cropping

Source: Kang *et al.* (1986)

ALLEY FARMING MANAGEMENT

Legumes are usually prefered as hedgerow material for alley farming, although some non-leguminous tree species could also be used. The more important factor is the suitability of the plant to the agro-ecological and soil conditions. According to Kang *et al.* (1984), results of several trials conducted in the humid and sub-humid lowland areas indicate that *Leucaena* and *Gliricidia* are the most suitable species for alley farming in these zones. Others (Wildin, 1986) have suggested that *Gliricidia* should be limited to the humid areas only, while *Sesbania grandiflora* can be incorporated into alley farming in both the humid and sub-humid areas. Other species that have been tested and found suitable for other agro-ecological zones and soil conditions are: for humid highlands, *Sesbania sesban* and *Cajanus cajan*; for semi-arid highlands, *Casia spectabilis* and *Calliandra*; and for humid lowlands with acid soils, *Acioa barterii* and *Ingas edulis* (Kang *et al*., 1984).

Hedgerow management

In the alley farming system, food crops such as maize and cassava are grown in 4-metre alleys between established trees which are pruned at various times to prevent shading of the crops. The prunings are applied as green manure and mulch to improve crop production. Okali and Sumberg (1985) suggested that, since the primary objective of the smallholder farmers is to obtain satisfactory crop yields, only 25% of the prunings should be fed to livestock and the rest used as mulch. Evidence exists, however, that the crop response varies with the stage of growth at the time of application of the mulch. Results from IITA suggest that prunings applied close to planting maize, for example, gave greater yield responses than those applied after tassling. Hence, as suggested by Kang *et al*. (1984), while all pre-planting prunings of alley trees should be used as mulch, all or a large part of later prunings could be fed to livestock without markedly depressing crop yields. In other words, a greater proportion of the foliage than suggested by Okali and Sumberg (1985) could be used as feed. Indeed most of the dry season prunings, when they are not needed for crops, could be used as fodder.

Studies need to be carried out to determine more precisely the optimum partitioning of alley farm prunings for use as mulch or fodder. The role of manure from animals should be quantified, together with the relative advantages of using tree foliage directly as mulch, or indirectly through animal manure.

Intensive feed gardens.

Alley farms could also be managed for fodder production only, by planting trees alone or in tree-grass combinations, in the intensive feed garden system. According to Atta-Krah (1989), this system is especialy suitable for livestock farmers willing to invest in pasture production.

In the tree-grass version, tree rows are spaced 2.5 or 4 metres apart with 2 or 4 rows of grass respectively in the alley. Yields of 20 tons of dry matter were reported for *Leucaena-Panicum maximum* combinations in the humid zone (Atta-Krah and Reynolds 1989). The productivity of tree-only plots, which allow more management flexibility, depends on interrow spacing and cutting frequency. Atta-Krah (1989) reported an annual yield of 30t dry matter/Ha from a combination of 0.5 m interrow spacing with a cutting interval of 12 weeks for *Leucaena*-only plots in the humid zone.

The intensive feed garden system has been evaluated by the ILCA Humid Zone Programme in East and Western Nigeria, where the average sheep and goat holding per household is about 3-4. It was reported that fodder from tree-only intensive feed gardens with an average size of 0.01 ha could provide sufficient browse in a cut and carry feeding system to meet 12.5% of the daily dry matter requirement of the animals.

BENEFITS AND PROBLEMS ASSOCIATED WITH ALLEY FARMING

Some of the documented benefits of alley farming include:

a. ***Soil improvement and conservation.*** Being deep rooted, alley trees extract nutrients from deep layers and return them to the surface in the litter. In addition to this beneficial nutrient recycling, legume species improve soil fertility through nitrogen fixation. Several workers (Kang *et al.*, 1984; Onim *et al.*, 1990) have shown that the addition of hedgerow mulch has favourable effects on soil physical characteristics (moisture infiltration and retention), chemical (high organic matter and nutrient status) and biotic (increased earthworm activity) properties. Surface soil cover with hedgerow prunings reduces runoff and soil erosion and woody hedgerow species planted on sloping land improve soil and water conservation (Lal, 1975).

b. ***Increased crop yield.*** Comparisons of crop yields under alley farm or traditional cultivation systems often show a yield advantage to alley crops (Table 2). Poor management of the hedgerow in terms of timing and utilisation of pruning in relation to crop growth cycle may, however, nullify this advantage.

c. ***Weed control.*** An often reported advantage of alley farming is weed control and suppression, through mulch cover (Lal, 1975) and shading. Jama *et al.* (1991) reported a 90% reduction in weed growth in alley plots of maize and *Leucaena*.

d. ***Improved animal productivity.*** Proper management of hedgerow plants, as indicated earlier, will ensure that browse is available for animal feeding during critical periods of scarcity. This fodder could be used as a supplement to poor quality grasses, crop residues and by-products. Evidence suggests that it could even be used as the sole feed for goats which have been shown to thrive on *Gliricidia* or *Gliricidia-Leucaena* combinations (Ademosun *et al.*, 1988). A summary of interesting results on the use of trees and shrub fodder for livestock feeding was presented by Smith in this volume.

TABLE 2. **Crop yield response to hedgerow mulching**

CROP	TREE SPECIES MULCH	RESPONSE % INCREASE OVER CONTROL	REFERENCE
Maize	Pigeon Pea	63.1	Onim *et al.* 1990
	Sesbania	75.5	
	Leucaena	68.2	
	Maize stover	38.1	
Maize	*Leucaena*	76	Jama *et al.* 1991
Maize	*Leucaena*	52	Akonde *et al.* 1986
	Gliricidia	43	
	Cajanus	35	

Labour requirements

The major problem with alley farming is the high labour input required to prune trees and incorporate mulch into the soil. ILCA workers estimated a labour requirement for pruning of 18 days/ha, which is higher than traditional labour requirements. Incorporation of a livestock component in a cut and carry system will further increase the daily labour requirement. Nevertheless, some data exist which show that labour required for clearing fallow land on alley farms is lower than that for fallow in the traditional farm. It is also claimed that, although more labour is required in alley farming, less fertilizer and herbicides are required. In other words, alley farming may indeed be economically viable in certain circumstances. Proper cost-benefit analyses are therefore essential.

FODDER BANKS

Fodder banks are enclosed areas of forage legumes reserved for dry season supplementary grazing of cattle (Saleem and Suleiman, 1986). The concept was developed in the humid zone of Nigeria by ILCA scientists and has been mainly tested in this area with some measure of success. The main objective of fodder banks is to overcome the protein deficiency of the grass which is of low quality in this zone and fluctuates seasonally, with protein content often going below the 6% required for adequate intake.

It is argued that including forage legumes in the diet of livestock would be of value here. Legumes were chosen because they are usually higher in protein and minerals, consumed better and have a higher digestibility than associated grasses at similar stages of growth. The legumes of choice relied on to date has been *Stylosanthes guianensis* cv. Cook and *S. hamata* cv. Verano. The guidelines worked out for establishing and managing a fodder bank, according to Saleem *et al.* (1986) are:

a. Fence a 4 ha piece of land. The land area was determined on the basis of earlier studies which showed that average herd population in the target area is 50, with 15 to 20 cows. With a yield of 4 to 5 t/ha of Stylo dry matter, it was calculated that this would supply enough supplementary feed for the more needy cows during the critical 6-month period of the dry season.

b. Prepare the seed bed by confining cattle overnight in the plot prior to the onset of the rains or by grazing down for 1 to 2 weeks after broadcasting seed or by harrowing if possible.
c. Broadcast scarified stylo seeds.
d. Control rapidly growing grasses and other weeds by grazing early in the growing season.
e. Allow forage to bulk up by deferring further grazing until the dry season.
f. Graze pregnant and lactating animals at a stocking rate of about 5 per ha for 2.5 hours per day, after the cattle return from bush grazing.
g. Ensure sufficient seed drop and enough stubble to remain for re-generation in the following season.

The fodder bank is usually located close to the homesteads to ensure proper management and minimise misuse.

Management of fodder banks

Fodder banks should be managed to ensure high productivity and dominance of the legume at the end of the growing season, as well as its persistence. Some of the factors identified as being important for long-term persistency of stylo in the fodder banks include: grazing pressure, soil fertility and fertilizer application, nitrogen output to the soil/plant system, other fodder species in the pasture and time of first rains (Saleem *et al.*, 1986).

Under controlled experimental conditions, these factors were addressed, and the productivity, quality and persistence of the legumes were satisfactory. During the testing and validation phase managed by the agro-pastoralists, certain changes were made to the proposed management package in order to reflect the realities of the terrain.

Some of these changes listed by Saleem *et al.* (1986) include :

a. Reluctance to confine cattle to the targeted plot for land preparation by trampling, as they were needed at the same time to manure crop fields. This resulted in poor seedbed preparation and hence lower yield.

b. The reluctance to graze cattle on freshly manured plots, to avoid worm infestation, resulting in a smothering of stylo by tall grasses.
c. The grazing of not just the pregnant and lactating animals in the herd as recommended but other animals in the herd that are equally stressed nutritionally, and for longer than recommended periods. The resultant overstocking led inevitably to lower persistence of the fodder bank.
d. The strategic change in the period of exploitation of the fodder bank from the dry season, as recommended, to the rainy season, to ensure that the animals entered the dry season with enough reserves to guarantee survival.

The results of these changes, which were rational to the farmer, were reflected in the reduced quantity, quality and persistence of farmer-managed fodder banks (Table 3).

TABLE 3. Effect of management on the yield, composition and persistence of stylo fodder banks.

PARAMETERS	AGE OF BANK (YRS)	STATION MANAGEMENT	FARMER MANAGEMENT
Total yield (kg DM/ha)	1	6824	7111
	2	7350	5278
	3	4748	-
	4	6546	-
Stylo yield (% total)	1	56	68
	2	55.4	64.5
	3	62	-
	4	61	-
Seeds recovered/m²	1	941	1529
	2	2839	1372
	3	2745	1824
	4	3102	-

This experience stimulated ILCA scientists to initiate remedial research. According to Saleem (1991), some of the new elements introduced to accomodate farmers concerns include: alternative land preparation methods to alleviate the fear of worm infestation; a search for productive disease-tolerant legume species to suit different ecological niches within the sub-humid zone, in order to ensure longer persistence; introduction of nitrogen-demanding cereal crops to alternate with years of legume growth to take advantage of and reduce soil nitrogen and reduce fertilizer input; the development of mini fodder banks of 0.25 ha adapted to small ruminant production by smallholders.

FUTURE PROSPECTS

Although the fodder bank concept has been shown to be a feasible, the rate of adoption by farmers has not been impressive. Perhaps not because of technical viability but due to socio-economic constraints such as land tenure insecurity and lack of infrastructural support. The technology was developed for the sub-humid zone and its central element, the Caribbean stylo, does not permit its extension outside the zone without further refinement. The length of the growing period in the drier areas is too short to support the generation cycle of the plant and, in the wetter areas, the challenge of anthracnose is too high. These limitations must be addressed in order to adapt the fodder bank concept to other regions.

CONCLUSION

The increasing demand for food in tropical Africa will continue to stimulate competition for the limited available land for crop and livestock production. An attractive solution to this problem is to encourage crop-livestock integration. Alley farming, intensive feed gardens and fodder banks provide for this integration and ensure a more rational and efficient use of the limited land resources. All three techniques have been shown to benefit the soil-plant-animal complex and should be exploited. Problem areas highlighted need to be examined and solutions found for adapting the systems to the different ecological regions.

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