Alley farming in the humid zone: Linking crop and livestock production*

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Summary

THIS PAPER *gives the background to small ruminant production in the humid zone of West Africa and describes the alley farming techniques which are being evaluated by ILCA's team based in Ibadan. The importance of crops in the zone is emphasised, to the extent that any improvement in livestock production should also show a positive effect on crop production. Alley farming employs the fast-growing leguminous trees Leucaena leucocephala and Gliricidia sepium which can provide both high-quality fodder for small ruminants and nitrogen-rich mulch for crop production. Crops are grown in alleys between rows of these leguminous trees.*

The cut-and-carry feeding of browse to small ruminants is expected to be one of the major benefits of alley farming. Alley farming also offers the possibility of allowing sheep to graze the fallow and the leguminous trees during periodic fallow years. A partial budget analysis of the two systems shows that short-term fallow grazing is competitive with continuous cropping.

During 1984, in a pilot development scheme of the Nigerian Federal Livestock Department, 60 participating farmers will plant 0.33 ha mixed browse alley farms and will start an animal health programme recommended by ILCA. ILCA's team will provide the browse seed, administer the health package and train the Ministry personnel in the principles and practices of alley farming.

Introduction

Ruminant livestock production in the humid zone of West Africa is limited by the disease trypanosomiasis. The most prevalent domestic ruminant species in the region are indigenous dwarf sheep and goats tolerant to trypanosomiasis. Of the 11 million of these animals in the zone as a whole, 8 million are found in the humid zone of Nigeria (ILCA, 1979).

In southwest Nigeria agriculture is dominated by the production of arable food and tree crops, including maize *(Zea mays* L.), yam *(Dioscorea* spp*.),* cassava *(Manihot esculenta),* cocoa *(Theobroma cacao)* and oil palm *(Elaeis guineensis).* Sheep and goats are kept by many rural households, but they are poorly integrated into the agricultural production system (Matthewman, 1980). The vast majority of small ruminants in this part of Nigeria are kept in free-roaming village flocks and are given only limited management or capital inputs. The average flock size is in the range of 2 to 5 animals per owner, with goats being more common than sheep. Feeding of household scraps is common, but the nutritional impact of this practice

is low. Few animals receive veterinary care, and mortalities within the first 3 months after birth are high.

Peste des petits ruminants (PPR) is perhaps the most important cause of early mortality, particularly among goats. Preliminary results from village trials show that PPR can be effectively and economically controlled by TCRV (Mack, 1982).

The work of the Humid Zone Programme

ILCA's Humid Zone Programme, based at Ibadan, Nigeria, aims to improve the productivity of indigenous breeds of sheep and goats in the zone. After disease, nutrition is probably the next most important factor limiting productivity. While it is difficult to demonstrate a seasonal feed shortage under present management conditions, there are compelling reasons why the feed situation deserves attention. PPR control is expected to reduce mortalities substantially, and thus should result in increased animal numbers and a greater demand for feed. Larger animal populations combined with the need to control animal movement around villages, gardens and farms are likely to result in some form of animal confinement. Total confinement of sheep and goats is already common in some parts of eastern Nigeria, and this necessitates cut-and-carry feeding and an easily accessible feed supply.

Because of the importance of crops in this zone, improvements in small ruminant production must also show a positive effect on crop production. For this reason ILCA's team is evaluating ways of linking crop and small ruminant production through the use of fast-growing leguminous trees such as *Leucaena leucocephala* and *Gliricidia sepium.* The foliage of these trees can be used both as high-quality fodder and as mineral-rich mulch for crop production.

Alley farming

Background

Kang et al (1981) described an alley cropping system developed by the Farming Systems Programme of the International Institute of Tropical Agriculture (IITA). In this system crops are grown in alleys 4 m wide between rows of densely planted trees which are pruned three to five times during each growing season. Trees managed in this way can produce 4 to 8 t of mulch DM/ ha, yielding over 100 kg N/ha/year for crop production. Alley cropping thus appears to be an attractive alternative to the traditional bush fallow system in that it can help to maintain soil fertility.

Small ruminant production can benefit from alley cropping through cut-and-carry feeding of the tree foliage, or, at a higher management level, by grazing both the natural fallow regrowth and the trees during periodic fallow years. Cut-and-carry browse feeding is applicable to both sheep and goats, while the grazing system is limited to sheep because goats damage the bark of the trees. ILCA's team is therefore investigating ways in which small ruminant and food crop production can be linked in an alley farming system.

When properly managed, the fast-growing leguminous trees *L. leucocephala* and *G. sepium* can together provide fodder throughout the year. Unlike grasses and some herbaceous legumes, browse trees show relatively little decline in nutritional quality during the dry season.

Cut-and-carry browse feeding

The cut-and-carry system of feeding a portion of the tree foliage to small ruminants is highly flexible and can be used with both free-roaming and confined animals. Depending on the availability and quality of other dodder resources, a range of browse feeding strategies can be developed. For example, browse may be fed as a protein supplement or as a sole feed. Browse can be fed on a year-round basis or solely during the dry season. Feeding browse to limited classes of animals, such as growing weaners or lactating dams, may be desirable in some circumstances.

Management

In order to give sufficient benefit to the crop and to ensure that nutrients are returned to the soil, the results of crop yield studies indicate that approximately 75% of the available tree foliage should be applied to the soil as mulch. An annual tree foliage yield of 4 t DM/ha would then give 1 t DM/ ha for feed. This amount would be sufficient to support approximately 14 adult animals/ha when used as a year-round supplement (25% of daily feed intake), or 4 animals/ha when used as a sole feed.

The management of browse trees within the alley farming context must take into account the requirements of the crop for nutrients and light, as well as the seasonality of demand for fodder. Year-round browse feeding, for example, will require a tree management strategy different from simple dry season supplementation. One aspect of ILCA's current research focuses on this relationship between tree management and feed requirements.

Supplementation trials

In two long-term browse supplementation trials, West African Dwarf sheep and goats are being fed varying amounts of a mixed-browse supplement together with an *ad libitum* basal diet. The objective of these trials is to determine the effect of browse supplementation on long-term dam productivity and short-term weaner growth. The basal diet consists of *Panicum maximum* of reasonable quality (fresh chopped, green, primarily vegetative growth). The diet is meant to mimic a diet of reasonable, but seasonally variable, quality which might be consumed by free-roaming animals in the humid zone.

Over a 14-week period a mixed *Leucaena/Gliricidia* browse supplement fed at approximately 200 g DM/doe/day increased the total intake of goats by 30% (Table 1). Fed at this level, browse constituted nearly 35% of the total dry matter intake. Browse supplementation of 200 and 400 g DM/ewe/day increased the total dry matter intake of sheep by 6% and 18% respectively. At 200 g DM/day, browse constituted 22% of dry matter intake, while with the ration of 400 g DM/day it accounted for 43% of the total intake.

Table 1. *The effect of controlled browse supplementation on daily dry matter intake by sheep and goats.*

Treatment		Total DM intake as % of basal diet only
Sheep	Basal diet only	100
	Basal + 200 g browse DM/ewe/day	106
	Basal + 400 g browse DM/ewe/day	118
Goats	Basal diet only	100
	Basal + 200 g browse DM/doe/day	130

Over a period of approximately 2 years the reproductive performance of dams and the survival and growth of offspring will be monitored. These trials will help determine the biological and economic values of browse supplementation to small ruminants in the context of alley farming.

Grazed fallow in integrated alley farming

Cut-and-carry browse feeding represents a highly flexible and relatively simple feeding strategy which can be implemented with a minimum of capital or management inputs. The grazed fallow approach with sheep will be somewhat more demanding in terms of management skills, but it represents a higher degree of integration of crop and livestock production activities since animal manure is returned to the soil.

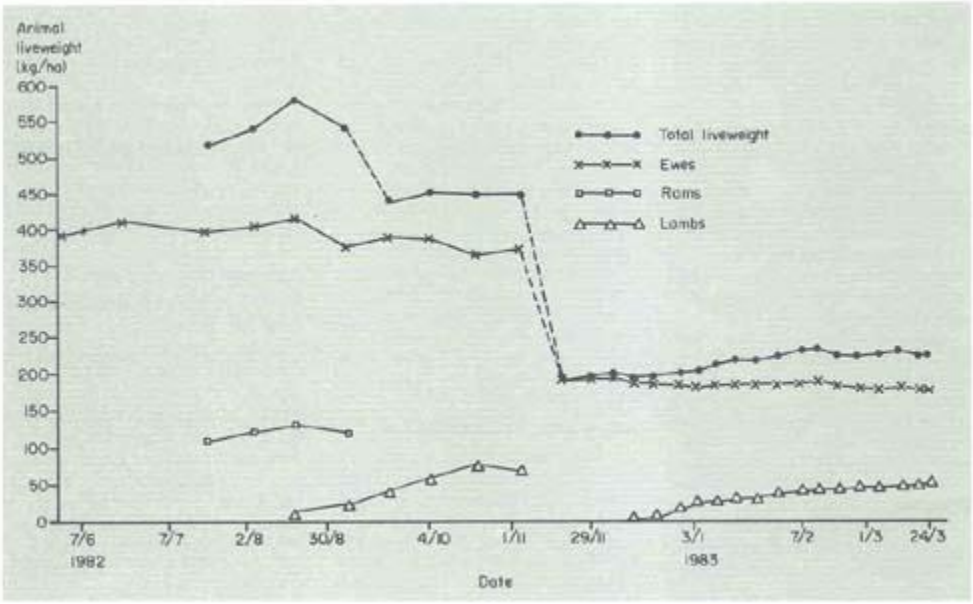
ILCA believes it may initially be easier to graze natural fallow vegetation in combination with browse trees than to establish and manage introduced pasture species for a short fallow grazing period. Future research may show that there are advantages in sowing high-producing grasses or herbaceous legumes for the proposed 2- or 3-year grazing periods between 3- to 5-year periods of alley cropping.

Paddock trials

In the preliminary evaluation of the grazed fallow system, two 0.25 ha paddocks containing natural fallow regrowth and the leguminous browse trees *Leucaena* and *Gliricidia* planted in rows 4 m apart were grazed by sheep for 10 months from June 1982 to May 1983. Ground vegetation, browse and animal performance were monitored in order to estimate appropriate stocking rates for such alley grazing systems and to identify potential problems and limitations of the system.

The components of animal liveweight supported per hectare during the grazing period are presented in Figure 1. From 1 June to 15 November, with a stocking rate of 16 ewes/ha, the paddocks supported an average of 472 kg liveweight/ha. Between 15 November and 31 March, with a stocking rate of 8 ewes/ha, they supported an average of 218 kg liveweight/ha.

Figure 1. *Components of animal liveweight supported by alley grazing over a 10-month grazing period, Ibadan, Nigeria, 1982–83.*



With the reduced stocking rate the animals were given a daily *Leucaena* supplement; each day two to three trees were bent and tied so that the upper foliage became available for consumption. This method of supplementation provided between 100 and 200 g DM/ewe/day and approximately 20 to 40 g CP/ewe/day. It would appear that the original stocking rate could have been maintained if supplementation had been started somewhat earlier.

During the rainy season the natural fallow vegetation provided an ample supply of good-quality herbage to support the stocking rate of 16 ewes/ha (Table 2). Standing dead plant material probably provided an important source of roughage during the dry season. *Leucaena* became an increasingly important component of the diet as the dry season progressed. Indeed, the success of this type of alley grazing system is dependent on the accumulation of browse during the wet season to supplement the diminishing ground vegetation in the dry season.

Table 2. *Monthly rainfall and feed components on offer during a 10-month grazing period, Ibadan, Nigeria, 1982–83.*

Month	Rainfall[a](mm)	Green grass (kg DM/ha)	Other green plants (kg DM/ha)	Dead plants (kg DM/ha)	*Leucaena* (kg DM/ha)	*Gliricidia* (kg DM/ha)	Total DM on offer (kg/ha)
J (1982)	1.6	–	–	–	–	–	–
F	44.6	–	_	–	–	–	–
M	92.7	–	–	–	–	–	–
A	87.9	–	–	–	–	–	–

M	124.4	–	–	–	–	–	–
J	166.7	566.7	1147.3	550.1	694.4	104.0	3062.5
J	136.9	1264.5	1869.0	460.1	968.7	111.7	4673.9
A	75.6	1441.8	2178.8	714.6	1086.1	129.2	5550.5
S	66.1	758.7	1574.7	929.8	727.5	92.5	4083.2
0	102.2	754.4	1642.3	851.0	1089.7	0.0	4337.4
N	8.9	507.8	1974.0	984.8	845.3	0.0	4311.9
D	0.0	115.9	681.8	1553.0	585.1	0.0	2935.8
J (1983)	0.0	0.0	0.0	1379.3	488.7	0.0	1868.0
F	3.9	0.0	0.0	1417.4	259.3	0.0	1676.7
M	3.2	0.0	0.0	1003.0	210.8	0.0	1213.8

[a] Rainfall data courtesy of T.L. Lawson, Farming Systems Programme, IITA.

Leucaena and *Gliricidia*

The height and flexibility of the *Leucaena* trees played an important role in restricting animal access during the wet season. At the end of the grazing period the *Leucaena* trees were as tall as 7 m. While the trees with thinner trunks (1 to 3 cm in diameter) were still being successfully browsed by the sheep, larger trees were no longer accessible. The method of controlled supplementation by bending trees daily worked satisfactorily and required a minimum of labour. After all foliage was consumed the trees were released and allowed to recover out of the reach of the animals.

Future alley farming systems could be based on a combination of tree species. Including several browse species may be advantageous in terms of diversity of diet, particularly if mimosine toxicity from*Leucaena* occurs. However, no adverse effects from *Leucaena* were observed during the course of this trial.

Gliricidia trees suffered heavy damage from the grazing animals, and the disappointing performance of these trees appeared to be due to the stake establishment method. Traditionally *Gliricidia* has been used for living fence posts and plantation shade, and for these uses stake establishment has obvious advantages. However, observations in Ibadan show that the root systems of trees established from stakes are shallow, less extensive, and have fewer and smaller tap roots than trees established from seed. It is unlikely that sheep would be able to

uproot seed-established *Gliricidia*trees, and certainly no problem of uprooting was seen with the seed-established *Leucaena.* It is believed that the deeper rooting system of sown *Gliricidia* plants will improve their dry season growth and retention of foliage, and their adaptability to more arid environments.

The branch damage that occurred during browsing also was related to the stake establishment method. Stake-grown trees tend to sprout and branch from the top of the stake, and it was these branches which were fund to be damaged. *Gliricidia* grown from seed can be managed to branch closer to ground level, and may be less susceptible to damage.

Budget analysis

A partial budget analysis of this alley grazing system comparing short-term fallow grazing with continuous cropping is presented in Table 3. At a stocking rate of 12 ewes/ha it would appear that a short-term grazed fallow period would be economically competitive with more traditional cropping activities. The grazed fallow period might also be advantageous with regard to improved soil fertility and crop yields. The effects of short-term grazed fallows on subsequent crop yields are currently being investigated in two major alley farming trials.

Table 3. *Partial budget analysis of alley grazing (incl. fallow) with sheep compared with continuous maize-cassava intercropping.*

System	US$/ha				
	Gross returns		Variable costs		Net returns
Alley grazing (12 ewes/ha)[a]	Weaners (16)	768	Labour	288	
	Adults (3)	288	Salt lick	29	
			Drugs	20	
	Total	1056		337	719
Maize-cassava In alleys[b]	Maize	985	Labour	808	
	Cassava	728	Seed/stakes	32	
			Fertilizer	128	
	Total	1713	Total	968	745

[a] Sale of weaners at 15 kg, adults at 30 kg at US$ 3.20/kg liveweight. Labour includes provision of water, checking of animals and tree management at 0.5 hr/day at US$ 1.00/hr. Cost of initial stock not included, but provision made for replacements. Assumes fertility rate of 1.3 lambs/ewe/year, and mortalities of 12,7 and 5% in the age groups 0–4 months, 4–12 months and adults respectively. Budget covers 18 months.

[b] Maize yield of 2.5 t/ha, cassava yield of 3.5 t/ha as intercrop. Maize sold at US$ 448/t, cassava at US$ 208/t. Labour at US$ 1.00/hr includes 25 days for pruning tree rows. Budget covers 18 months.

Preliminary observations thus indicate that alley grazing using short-term fallows and fast-growing trees is a promising approach to the integration of crop and livestock production in the humid zone of West Africa. The main advantages of the system are the relatively low capital and management requirements.

Several areas need further study, particularly the tree management aspects in the transition from cropping to grazing and grazing to cropping. Factors affecting the species composition and productivity of natural fallows also need clarification. In this regard, the effects of different weed control strategies during cropping years on the composition and productivity of subsequent fallow vegetation are being studied.

Browse and alley farming in West Africa

Small ruminant production is a common minor farm enterprise throughout the humid zone of West Africa, and improved feeding will certainly be an important component of intensified and/or more efficient production systems. ILCA is currently investigating the management and use of intensive 'feed gardens' in eastern Nigeria where animal movement is commonly restricted, necessitating daily cut-and-carry feeding.

Alley farming is an innovative production technique which has sufficient promise to be tested under a variety of conditions throughout the region. *Leucaena* and *Gliricidia* are the browse species most widely tested in alley farming, and while other potentially useful species are under investigation, ILCA's work will continue to centre around these two versatile species. Through the collection and evaluation of new *Gliricidia* germplasm, ILCA's team hopes to identify types which are more productive than the present material and better adapted to more arid environments. This unique genetic resource will be evaluated under as wide a range of environmental and management conditions as possible.

ILCA's team is at present evaluating 16 village alley farms. The team is now set to play a central role in a new pilot development scheme of the Federal Livestock Department of Nigeria. During 1984, 60 participating farmers will plant 0.33 ha mixed-browse alley farms and will start a health programme including TCRV vaccination. ILCA's team will provide the browse seed, administer the health package, and train Ministry personnel in the principles and practices of alley farming.

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