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Alley Farming in the Humid and Subhumid Tropics

Proceedings of an international workshop held at Ibadan, Nigeria, 10–14 March 1986

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Alley Farming in the Humid and Subhumid Tropics

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Editors: B.T. Kang and L. Reynolds

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Abstract / Résumé / Resumen

Abstract — An urgent challenge facing scientists working on upland food-crop production in many parts of the humid and subhumid tropics is the need to find viable, sustainable, and environmentally sound alternatives to the ancient shifting cultivation and bush-fallow, slash-and-burn cultivation systems. As a food-cropping and livestock-production technology, alley farming requires a low level of inputs and helps conserve soil resources while sustaining long-term farm productivity. This publication presents the results of an international workshop on alley farming in the humid and subhumid tropics. Held in Ibadan, Nigeria, 10–14 March 1986, the workshop was attended by 100 participants from 21 countries. The theme of this workshop was the development of more productive, sustainable farming methods with low inputs in the humid and subhumid tropics using alley farming techniques. This book reviews the present state of alley farming research and its application, discusses the use of woody species in tropical farming systems, highlights training and research needs, and proposes the establishment of channels for collaborative research.

Résumé — Les scientifiques s'intéressant aux cultures vivrières en zones d'altitude dans de nombreuses régions des tropiques humides et sub-humides doivent répondre à un besoin urgent : trouver des solutions de rechange viables, soutenables et environnementalement saines aux anciennes méthodes de rotation des cultures et mise en jachère et de culture sur brûlis. A titre de technique de culture et d'élevage, l'agriculture en couloirs ne nécessite que peu d'intrants et contribue à conserver les sols, tout en favorisant la productivité agricole à long terme. Cette publication présente les résultats d'un atelier international sur l'agriculture en couloirs dans les tropiques humides et sub-humides qui s'est tenu à Ibadan, au Nigéria, du 10 au 14 mars 1986 et qui a réuni 100 participants de 21 pays. L'atelier portait sur la mise au point de méthodes culturales plus productives et plus durables ne nécessitant que peu d'intrants pour les régions des tropiques humides et sub-humides, grâce aux techniques de l'agriculture en couloirs. Le livre fait le point sur la recherche actuelle en matière d'agriculture en couloirs et ses applications, discute de l'utilisation des arbres dans les systèmes agricoles en milieu tropical, met en lumière les besoins en matière de formation et de recherche et propose l'établissement de canaux aux fins de la recherche en collaboration.

Resumen — Un reto urgente al que se enfrentan los científicos que realizan investigaciones sobre la explotación de cultivos de montaña en muchas zonas húmedas y subhúmedas de los trópicos, es la necesidad de encontrar alternativas viables, sustentables y correctas desde el punto de vista del medio ambiente, al antiguo método de cultivos migratorios y a los sistemas de cultivo en barbecho y de corte y quema. Como tecnología utilizada para cultivos alimentarios y la producción ganadera, la agricultura de pasillo o entresurcos necesita pocos medios y ayuda a conservar los recursos del suelo en tanto mantiene la productividad agrícola a largo plazo. Esta publicación presenta los resultados de un grupo de trabajo internacional sobre agricultura de pasillo o entresurco en las zonas húmedas y subhúmedas de los trópicos, celebrado en Ibadán, Nigeria, del 10 al 14 de marzo de 1986, y al que asistieron 100 participantes de 21 países. El tema de este grupo de trabajo fue el desarrollo de métodos de cultivo más productivos y sostenidos con pocos recursos en las zonas húmedas y subhúmedas de los trópicos, utilizando técnicas de agricultura de pasillo o entresurco. Este libro revisa la situación actual de la investigación sobre la agricultura de pasillo o de entresurco y su aplicación, discute el uso de especies maderables en sistemas de cultivo tropicales, subraya la necesidad de realizar investigaciones y dar cursos de capacitación y propone la creación de canales para la investigación conjunta.

Contents

Alley cropping in the coastal area of Kenya

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Abstract — *On-station and on-farm trials were carried out using multipurpose or leguminous trees and shrubs. The research partly focused on testing these woody species for enhancement of crop and livestock feed production and improvement of soil fertility. This paper reports some of the results obtained with* Leucaena, Sesbania, Casuarina, Gliricidia, *and* Acacia albida *in the coastal area of Kenya. Woody species established well in the coastal region. Maize intercropped with woody species in the 2nd and 3rd year showed low yields, particularly at higher tree densities. Prunings of* Leucaena *and* Gliricidia *hedgerows produced substantial amounts of biomass and nitrogen. In the 3rd year after establishment and following hedgerow prunings, maize alley cropped with* Leucaena *yielded more than the control plot. Tree establishment improved soil fertility and reduced weed infestation. In 3 years,* Leucaena *and* Casuarina *can produce 175 t/ha and 86 m^3/ha of commercial wood, respectively.*

Introduction

The coastal area of Kenya is both ecologically and economically distinct from the rest of the country. Its rapid socioeconomic development and high population growth rate have resulted in high rates of environmental degradation because of increased food-crop farming and deforestation.

Annual rainfall is highly variable, ranging from 600 to over 2 000 mm. During the period of the experiment (1982–1985), annual rainfall ranged from 1 288 (1983) to 1 938 mm (1982). There are two short growing seasons: April–July and October–December.

Soils are generally highly leached and inherently infertile. The soils of the experimental site are sandy, acid, and low in organic matter, cation exchange capacity, and nutrient status. Maize yield in the area is generally low (900–1 000 kg/ha); nitrogen is required for good yields. Weeds are a major problem and can result in losses in crop yield. Weeding can occupy 40–50% of the farmers' time.

The combination of low soil fertility and weed problems suggests that alley cropping might be a more suitable land-use system for the coastal lowlands of Kenya. The tree component of this system would provide nutrients to the soil and diversified farm produce to farmers and the community (food, livestock feed, fuelwood, etc.).

Long-term agroforestry and alley cropping experiments were initiated in mid-1982. Selected tropical, multipurpose tree or shrub species (MPTs) were used. The experiments had the following objectives:

- to assess the performance of woody species in the coastal environment;
- to assess the interaction of MPTs on associated food crops when intercropped;
- to determine the fuelwood yield of woody species in the agroforestry system; and
- to assess the potential of agroforestry and alley cropping as a land use system.

Some of the results of these experiments from 1982 to 1985 are discussed here.

Experimental design

Several MPTs, including leguminous species, were screened and long-term research and demonstration plots were established. Species tested in the agroforestry and alley cropping experiments included *Gliricidia sepium*, *Leucaena leucocephala*, *Sesbania grandiflora*, *Acacia albida*, and *Casuarina equisetifolia*.

A parallel systematic design (Huxley 1983) with 2, 4, and 8 m between rows, 0.5, 1, 2, and 3 m within rows, and an east–west row orientation was used (Fig. 1). The MPTs were established with a cassava crop. Subsequently, maize was planted between the hedgerows during the long rainy seasons of 1983 and 1984. Because of canopy closure and severe competition from the hedgerows, hedgerow sides were pruned in 1984. In 1985, *Leucaena* and *Gliricidia* hedgerows were pruned before maize cropping, primarily to reduce shading. The planting density and crop husbandry practices recommended by the Ministry of Agriculture and Livestock Development were used. Maize was planted at a density of 90 × 30 cm (one maize plant per hill) (Muturi 1981). Fertilizer was applied to all plots at the rate of 36 kg N/ha (calcium ammonium citrate) and 44 kg P_2O_5/ha (triple superphosphate).

Results and discussion

MPT establishment

Cassava was used as the initial companion crop in May 1982 to establish woody species. It was harvested about 1 year later. The survival and growth rate of all species except *S. grandiflora* was good (Table 1). This was true even when trees and shrubs were intercropped with food crops. MPTs continued to perform well during this initial establishment phase.

At high and low densities, trees and shrubs grew equally well. Tree height is affected little by inter- and intrarow spacings (Table 2), especially during the first 3 years after establishment. Row width and line density have a significant effect on biomass yield: highest yields are attained with 2- and 4-m interrow and 0.5- and 1.0-m intrarow spacings. At these high density ranges, optimum biomass was

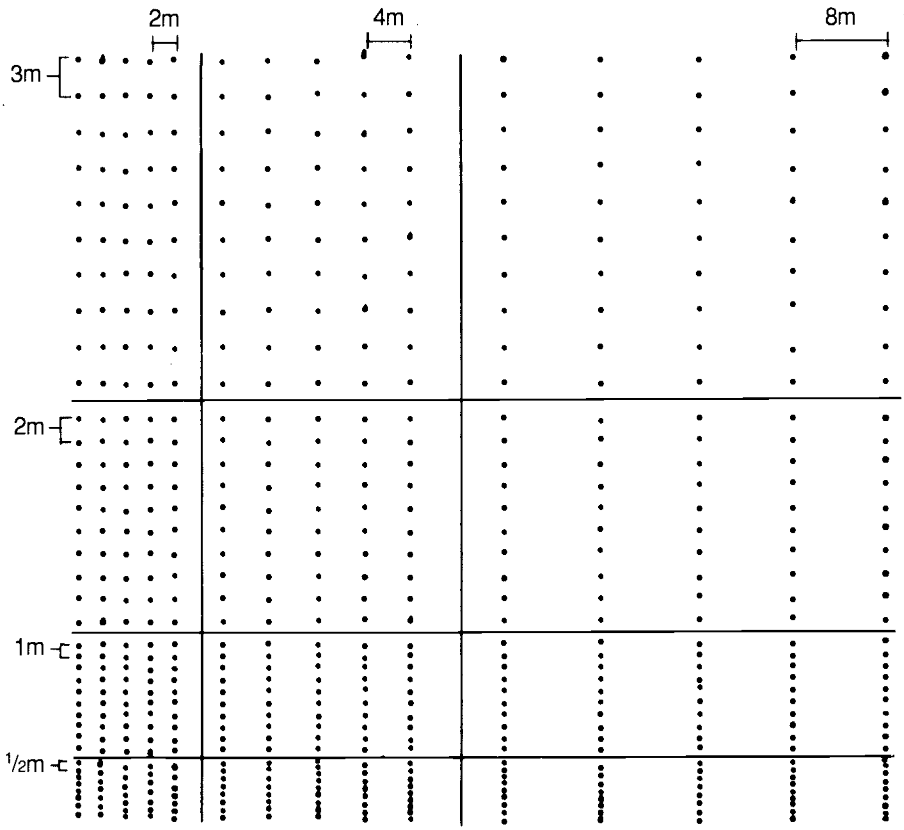

Fig. 1. Layout used in the research and demonstration plots.

reached at 26–30 months for *Casuarina*. Low density ranges (8-m interrow spacing) required longer cutting cycles. This situation results in high revenues from wood, particularly if it is sold for poles as was *Casuarina*. The increase in wood yield more than compensated for the decline in the 1984 crop yield (Table 3). Tree canopy closure was realized after 18 months with the 2-m interrow spacing and, to a lesser extent, with the 4-m interrow spacing. This resulted in less weed infestation.

Crop performance

Moisture stress and shading in the 2-m alleys and, to a lesser extent, the 4-m alleys became severe 1 year after establishment. This is evident from the effects of *Casuarina* on 1983, 1984, and 1985 maize yields (Table 3). The 1984 maize yield under *Casuarina* was particularly low compared with 1983 and 1985 because of the low rainfall in 1984 (Table 3). Maize yields for 1985 were lower than 1983 yields because of increased shading and competition from woody species.

Similar trends were observed with crops grown under *Gliricidia* and *Leucaena* (Tables 4 and 5). The low 1984 maize yields were aggravated by poor seasonal rains.

Table 1. Survival (%) and mean plant height (cm) after the 1st year of selected woody species established with cassava at Mtwapa, Kenya.

Species	Survival	Mean height
Acacia albida	72	144
Casuarina equisetifolia	99	251
Gliricidia sepium	82	288
Leucaena leucocephala cv. K-28	83	371
Sesbania grandiflora[a]	67	33

[a] Mostly from direct sowing because of low survival rate from seedlings.

Table 2. Plant heights (Ht, m) and breast-height (1.3 m) diameters (dbh, cm) of selected woody species in 2, 4, and 8 m wide alleys after 3.5 years at Mtwapa, Kenya.

	2 m		4 m		8 m		Average	
Species	Ht	dbh	Ht	dbh	Ht	dbh	Ht	dbh
Acacia albida	4.4	8.6	5.1	10.0	5.8	11.6	5.1	10.1
Casuarina equisetifolia	8.7	11.8	10.6	12.6	12.3	12.0	10.5	12.1
Gliricidia sepium	5.7	5.5	4.9	5.4	4.5	5.1	5.1	5.3

Table 3. Effect of *Casuarina* hedgerows on maize yield (kg/ha) during the first 3 years after establishment at Mtwapa, Kenya.

Intrarow spacing (m)	Interrow spacing: 2 m			4 m			8 m		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
0.5	350	180	250	2020	460	300	3000	1610	600
1.0	530	60	375	1430	325	250	2750	1038	413
2.0	1830	240	386	3870	625	275	3820	1088	413
3.0	1530	347	567	3900	625	300	2250	1084	533
Mean	1060	207	394	2805	509	281	2955	1205	490
Control (no trees)				3000	2750	2550			
District average				2500	1800	—			
Seasonal rainfall (mm)				1063	906	1174			

Note: Side trimming was done in September 1984 in the 2- and 4-m interrow spacings to reduce shading.

Table 4. Effect of *Gliricidia* hedgerows on maize yield (kg/ha) at Mtwapa, Kenya.

Intrarow spacing (m)	Interrow spacing 2 m 1984	2 m 1985	4 m 1984	4 m 1985	8 m 1984	8 m 1985
0.5	600	3000	380	2650	1798	1650
1.0	180	2400	190	2025	1020	1700
2.0	410	2478	860	2625	921	1425
3.0	243	1950	558	2167	1183	1450
Mean	358	2457	304	2367	1230	1556
Control (no trees)			2750	2526		
District average			1800	—		
Rainfall (mm)			906	1174		

Note: In 1984, hedgerows were under 2 years old and unpruned. During the 1985 cropping, hedgerows were pruned to a height of 10–15 cm.

Table 5. Effect of *Leucaena* hedgerows on maize yield (kg/ha) at Mtwapa, Kenya.

Intrarow spacing (m)	Interrow spacing 2 m 1984	2 m 1985	4 m 1984	4 m 1985	8 m 1984	8 m 1985
0.5	0	4000	90	3400	250	3100
1.0	0	3600	0	2675	205	2475
2.0	0	3600	15	2363	619	3100
3.0	16	2500	196	2683	107	2033
Mean	4	3425	75	2780	295	2677
Control (no trees)			2750	2526		
District average			1800	—		
Rainfall (mm)			906	1174		

Note: In 1984, hedgerows were under 2 years old and unpruned. During the 1985 cropping, hedgerows were pruned to a height of 10–15 cm.

Because of the dense canopy, *Leucaena* and *Gliricidia* hedgerows were cut back to single stems during the green gram crop season (September–December 1984). Despite the long dry season (December–March), there was good regrowth of the hedgerows. In mid-March 1985, 2 weeks before maize planting, *Leucaena* and *Gliricidia* hedgerows were cut back and subsequently pruned at intervals. This reduced shading on the associated maize crop and provided mulch and green manure.

Substantial amounts of biomass were obtained from these prunings (Table 6). They also yielded a substantial amount of nitrogen: from 48 kg N/ha with 8-m

Table 6. Fresh biomass yield (t/ha) of *Leucaena* hedgerows from three prunings, March–May 1985.

Intrarow spacing (m)	Interrow spacing			
	2 m	4 m	8 m	Mean
0.5	28.3	18.3	12.1	19.5
1.0	17.4	8.6	6.2	10.7
2.0	13.9	6.5	4.6	8.3
3.0	11.3	8.2	4.8	8.1
Mean	17.7	10.4	6.9	11.7

interrow and 3-m intrarow spacings to over 280 kg N/ha for 2-m interrow and 0.5-m intrarow spacings.

When alley cropped with *Leucaena* or *Gliricidia*, maize yields increase (Tables 4 and 5). This is because of soil enrichment by woody legumes and the addition of the prunings (Table 6). Yields of the alley-cropped maize in 1985 also showed a significant interaction (at 5% level) with increasing inter- and intrarow hedgerow spacings (Table 5).

Weed infestation

The plots gradually became less infested with weeds during the period of tree-establishment. As the hedgerow canopy closed at about maize harvest time, particularly with the 2- and 4-m interrow spacings, weeds disappeared. As weeds disappear, the amount of labour devoted to weeding decreased.

Weed infestation in the alley plots was significantly lower during the dry season between the cropping seasons than in the control plot (no trees). In the *Leucaena* alleys, most of the weeds were broad-leaved species. Compared with the grasses and sedges (nut grass) in the control plot, these species are easily removed.

Soil properties

The nutrient status of the surface soil distinctly improved in the alley cropped plots compared with the control plots. Soil pH also increased over time in the alley cropped plots. The nutrient status (N, P, K, Ca, Mg) of the soil also increased with an increase in tree density. The 2-m interrow spacing showed the highest nutrient levels.

Financial returns

All woody species, except *S. grandiflora*, showed high wood yields and associated fresh and green biomass yields. The wood represents an important source of income and a much-needed product for both rural and urban populations. Its yield eclipsed the decline in crop yields during the 2nd and 3rd years. The annual net income from the wood of *Casuarina* (used mainly for construction

Table 7. Annual net farm income (KES/ha)[a] from a 3-year-old *Casuarina* food crop agroforestry system at Mtwapa, Kenya.

Intrarow spacing (m)	Interrow spacing 2 m	4 m	8 m
0.5	44000	26000	16000
1.0	27700	14300	9000
2.0	15700	9000	5700
3.0	10300	6700	3300
Control (agriculture only)		7300	
Forestry control		2000	

[a] In November 1988, 16.9 Kenyan shillings (KES) = 1 United States dollar (USD).

poles) under an agroforestry system compared with forestry and agriculture showed that an agroforestry system is more productive than crop farming alone (Table 7).

Conclusions

A tree-based land-use system, particularly an agroforestry system, appears to be a suitable system for the tropical coastal lowlands of Kenya. The system can effectively overcome environmental constraints such as poor soils and weed infestation. It can exploit more effectively the positive features of the environment (i.e., radiation, temperature, and rainfall). Growing trees in an agroforestry system is usually effective because crop husbandry (land preparation, weeding, fertilization, etc.) greatly benefits the woody species.

High tree densities (2 500–10 000 trees/ha) result in better weed suppression, improved soil fertility, and shorter wood-harvesting cycles. With leguminous woody species such as *Leucaena* and *Gliricidia*, which are destined for alley cropping, a deep and extensive root system is established. Consequently, woody species are better able to withstand periodic pruning. Therefore, the first pruning should occur at least 18 months after planting.

Unpruned trees severely depress maize yield because of shading. When *Leucaena* was pruned to reduce light competition and the foliage was used for mulch, higher maize yields compared with the control plots were realized at the higher interrow and intrarow densities of *Leucaena*.

Acknowledgments

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