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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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 Nigeria, 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 quemar. Como tecnología utilizada para cultivos alimentarios y la producción ganadera, la agricultura de pasillo o entrecurcos 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 entrecurso 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 entrecurso. Este libro revisa la situación actual de la investigación sobre la agricultura de pasillo o de entrecurso 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.
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Alley cropping under semi-arid conditions in Kenya

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Abstract — The Dryland Agroforestry Research Project was designed to test several agroforestry interventions aimed at reversing the constraints that have recently appeared in the semi-arid lands of Kenya as a result of population pressure. These constraints were discovered following the application of the International Council for Research in Agroforestry's diagnosis and design methodology to a typically semi-arid area in eastern Kenya. One of the intervention technologies designed to counteract these constraints is alley cropping. This paper describes on-station and on-farm alley cropping experiments. The trials are still in their initial stages and it is too early to say whether alley cropping will be successful in the semi-arid areas of Kenya.

Introduction

In Kenya, rapid population growth (about 3.8–4.0% annually), limited arable land, and a shortage of employment opportunities in the industrial and service sectors have led to an increase in the number of smallholders farming and ranching on Kenya’s marginal, semi-arid lands. This trend is expected to continue into the 21st century.

Increased settlement and exploitation of these semi-arid lands provide a basis for the livelihood of small-scale farmers; however, the results are mixed. The soils, especially those on the steeper slopes, are subject to serious erosion. Much of the rangeland has been overgrazed and the ground cover in some areas is badly degraded. Also, rainfall in the semi-arid zone is low (600–800 mm) and subject to considerable variability.

These factors, combined with traditional methods of farming and ranching, have led to a low standard of living for many rural inhabitants in these areas. When rainfall is deficient, the Government of Kenya has diverted scarce treasury funds to famine relief for those most seriously affected. Moreover, the resulting depletion of the natural resources (forestry included) does not augur well for future generations who are expected to live on these marginal lands.
A preinvestment inventory study of the marginal semi-arid lands in Kenya conducted during 1977 and 1978 found that major investments in soil conservation, farm-production technology, and infrastructure are needed to reverse the rapid decline in the quality of life and the condition of the physical environment in the semi-arid lands.

Several institutions are now geared to fulfill this goal. The Katumani Research Station, in collaboration with the Food and Agriculture Organization of the United Nations (FAO), the Kenya Agricultural Research Institute (KARI), and the United States Agency for International Development (USAID) are trying to determine appropriate agricultural systems for the semi-arid areas; the European Development Fund is also sponsoring an integrated development program in Machakos District. Most research so far has focused on purely agricultural or livestock systems, although the potential role of trees has been clearly recognized by each of these institutions. In this context, an agroforestry research project becomes an important and appropriate contribution to the overall development of the semi-arid lands. Machakos District was selected for a 4-year pilot project on dryland agroforestry financed by the International Development Research Centre (IDRC). The project began in September 1983.

Fig. 1. Location of the research site and recommendation domain in Machakos District, Kenya.
The target area

The Kakuyuni catchment area, located in Machakos District on the Yatta Plateau, falls within agroclimatic zone 5 (Sombroek and Siderius 1982), a semi-arid region of about 1 million ha (69% of the district's land area), and supports 465,000 people (43% of the district's population, 1979 census). Kakuyuni is considered to be representative of the more densely populated areas of zone 5, where farmers are more dependent on agriculture than grazing (Fig. 1).

Terrain and soils

The catchment area is about 1,200 m above sea level and the terrain is gently to moderately sloping. Soils in the catchment area are well drained, shallow to deep, dark red, friable clay, and rocky in many places (Nito Rhodic Ferralsols and Nito Chromic Cambisols, including lithic and bouldery phases). In some depressions, a poorly drained, dark greyish-brown to black, firm, slightly calcareous, cracking clay can be found with a saline and sodic deeper subsoil (Pellic Vertisols) and a partly saline–sodic phase (with eutric or vertic Gleysols) (Sombroek and Siderius 1982).

The Ferralsol–Cambisol soil association, including rocky phases, suffers from low inherent fertility once the organic matter content is diminished by arable cropping; it also has a low capacity to retain added nutrients. Maintaining or raising the organic matter content is thus of particular importance.

The dark Vertisols found in poorly drained depressions are difficult to cultivate as they are sticky and stiff when wet and hard when dry. The poor drainage is also a problem for most crops other than rice.

Climate

In the Kakuyuni area, optimal water requirements \(E_0\), on average, are only met in November. The lower limit of normal plant water needs \(0.4 E_0\) is exceeded by precipitation only in April, November, and December (Fig. 2). These unfavourable climatic conditions are further aggravated by the seasonal and yearly variation in rainfall (Table 1). The names “long rains” and “short rains” (Table 1A) are somewhat misleading in the survey area, as the rainy period of October–December (short rains) is longer than the long rains from March to May. Furthermore, the amount and probability of rainfall from October to December is higher (Table 1B). Therefore, the October–December rainy season poses less risk to cropping activities.

Vegetation

The dominant tree–shrub vegetation in the area is mainly Combretum molle, Acacia abyssinica, Balanites aegyptiaca, and Terminalia brownii. These species are mainly found on red clay soils; Acacia drepanolobium is common on black clay soils.
The diagnosis and design methodology of the International Council for Research in Agroforestry (ICRAF) was used to identify research needs for the target area. The diagnostic and prediagnostic data collected from the Kakuyuni area indicated the following characteristics:

- low productivity of crops as a result of low soil fertility (low organic matter and nitrogen levels);
- high rate of soil erosion and runoff;

**Dryland agroforestry research project**

Fig. 2. Mean annual precipitation (shaded area), potential evaporation (solid line), and potential evapotranspiration (dashed line) throughout the year in the Kakuyuni area (Woodhead 1968; Kenya Meteorological Department).
Table 1. Rainfall on the project site.

(A) Projected onset and cessation.

<table>
<thead>
<tr>
<th>Description</th>
<th>Onset</th>
<th>Cessation</th>
<th>Duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long rains</td>
<td>12–16 Mar.</td>
<td>1–5 May</td>
<td>50</td>
</tr>
<tr>
<td>Short rains</td>
<td>18–22 Oct.</td>
<td>22–26 Dec.</td>
<td>60</td>
</tr>
</tbody>
</table>

(B) Seasonal probability (%).

<table>
<thead>
<tr>
<th>Period</th>
<th>&gt;100 mm</th>
<th>&gt;150 mm</th>
<th>&gt;200 mm</th>
<th>&gt;250 mm</th>
<th>&gt;300 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar.–May&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75</td>
<td>54</td>
<td>38</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Oct.–Dec.</td>
<td>96</td>
<td>90</td>
<td>74</td>
<td>58</td>
<td>39</td>
</tr>
</tbody>
</table>

Source: Jaetzolf (1979)

<sup>a</sup> Mean March to May rainfall, 195 mm.

<sup>b</sup> Mean October to December rainfall, 305 mm.

- shortage of animal fodder, especially during the dry season;
- shortage of fuelwood and building poles; and
- shortage of cash (no cash crops).

Project objectives

The project aims to develop agroforestry technologies for the semi-arid areas of Kenya and other East African countries, with a view to improving the quality of life of the inhabitants. Following the identification of constraints, the following project objectives were specified:

- to examine the possibilities of maintaining or increasing productivity by establishing alley cropping;
- to examine the possibilities of improving the quality, quantity, and seasonal distribution of forage on the farm by planting fodder tree or shrub species in the grazing areas and by developing cut-and-carry forage systems;
- to examine the possibilities of reducing the labour requirements of the free-grazing system and fuelwood collection by establishing live fences around grazing land and planting fuelwood species on the farm; and
- to examine the possibilities of increasing the cash income of the farmers by the introduction of fruit trees.

Most of the project objectives have been initiated. A summary of the alley cropping trials is presented here. For detailed discussions, descriptions of experimental layout, and data analysis, see Arap-Sang et al. (1985) and Arap-Sang and Hockstra (1986a, b, c).
Leaf-manuring trials

As a forerunner to alley cropping trials, a small trial was initiated to screen the effect of different tree leaves and their rates of application on plant growth. The leaves were incorporated into the soil. Beginning in October 1983 at Katumani National Dryland Farming Station, Maruba Farm, the trial used four replications: *Cassia siamea*, 1 and 2 kg/m² (fresh weight); *Leucaena leucocephala*, 1 and 2 kg/m²; *Terminalia brownii*, 1 and 2 kg/m²; and control (no leafy material applied).

The leafy material was applied about 2 weeks before planting and incorporated into the soil immediately to prevent the wind from blowing it away. To minimize the influence of slope, small ridges were made around each plot.

For the test crop, beans (*Phaseolus* spp.) and maize (*Zea mays*) were applied. Each plot had one row of 10 bean plants, with 15 cm between each plant. Each plot had one row of 6 maize plants, with 30 cm between each plant.

To observe the effect of continued green manuring on the same piece of land, the experiment was performed in March 1984 at the onset of the long rains, in October 1984 during the short rains, and in both seasons of 1985. To screen as many species and rates as possible with the limited amount of land available, very small plot sizes were used. This technique exposes relative differences between treatments rather than absolute differences. For this reason, yield values cannot be extrapolated to a per-hectare basis.

A larger experiment was established in May 1985 to obtain more reliable yield values (Arap-Sang and Hoekstra 1986a, c). To date, only one season’s results have been analyzed.

Hedgerow trials

On-farm hedgerow trials were initiated during the short rains of 1985 on one farmer’s plot. Two species were used: *Gliricidia sepium* and *Leucaena leucocephala*. Three more plots have been prepared for trials with *Sesbania sesban*, *Calliandra calothyrsus*, and *Gliricidia sepium*. The trials have four main objectives:

- to study the effect of hedgerows on maize yield;
- to study the effect of different intrarow tree spacings on the yield of maize in the alleys;
- to study the effect of proximity to the hedgerows on the yield of maize; and
- to study the “side of hedge” effect on maize yield.

Results and discussion

Leaf-manuring trials

Results of the first three cropping seasons with maize have been reported in detail by Arap-Sang et al. (1985). *Leucaena leucocephala* at 2 kg/m², *Terminalia brownii* at 1 kg/m², and *Cassia siamea* at 2 kg/m² gave the best results for plant
height, leaf area index, and grain weight. *Terminalia* at 2 kg/m² somehow inhibited these parameters; the reason for this observation is still unknown.

Preliminary results from trials elsewhere in Machakos District gave green matter yields for *Leucaena* of about 1.5 kg/tree per season at an average intrarow spacing of 0.62 m and between-row spacing of 3.5 m. Per-hectare production of leafy material per season was, therefore, approximately 6 900 kg; distributed over a crop area of 6 600 m² (one-third of the total area being occupied by the hedges), application rate was about 1 kg/m². At this rate, the relative yield of maize per unit of crop area increased by only 22%. In the case of *Leucaena*, this would be insufficient to offset the reduction in yield as a result of land loss (33%). No biomass figures are available for *Terminalia*.

During the fourth cropping season, a significant, positive difference (36–122%) was observed between treated and control plots. Whether this improved performance can be attributed to the cumulative green-manuring effect or to other factors may be determined through a proper soil analysis (in progress). The negative effects of *Terminalia brownii* prunings applied during the third cropping season at 2 kg/m² were not observed in the fourth cropping season. No conclusive results have been obtained over the three cropping seasons with beans as the test crop.

In the large-field trial, the response of maize yield to the application of green manure from tree leaves was inconclusive during the first cropping season (Arap-Sang and Hoekstra 1986c). The response from *Leucaena* was directly related to treatment level. It is expected that the treatment effects will be more consistent once soil fertility has become a more critical factor because of continuous cropping.

**On-station hedgerow trials**

Because hedgerow trials are still in the developmental stage and because of their limited scope, they have prompted no definite conclusions. Most of the preliminary results are of an exploratory nature, offering some interesting clues to how the system might perform as well as clues to some of the factors affecting performance.

During the development phase of the alley cropping system, hedges seem to have had both positive and negative impacts on the stover and grain production of the maize grown in the alleys. In the first three cropping seasons, the positive impact outweighs the negative. The positive impact is probably due to the sheltering effect of the hedges. Wind direction (east–west) is almost perpendicular to the hedgerow direction (north–south). With an average pruning height of 50 cm, the maize plant between the hedgerows can obtain complete protection. Especially during the early growth stages, when the individual maize plants are not yet tall enough to provide each other shelter from wind, the plants between the hedges could be at an advantage compared with the maize plants in the control plots.

In the fourth and final cropping season, the shelter offered by the hedges is neutralized by its negative impact on the maize. Such an impact is closely related to the growth of the hedges and is likely due to competition for moisture between the hedges and the adjacent rows of maize. These findings indicate that maize loss during the early days of hedgerow development can be minimized, provided the hedgerows have the proper orientation with respect to wind direction.
With regard to the two in-row spacings of *Cassia siamea*, during hedgerow development, no significant differences were observed in their interaction with the maize rows. The 0.25-m intrarow spacing, however, showed a considerably higher mortality rate in periods of drought; at the same time, more labour and seedlings were required to establish this plot (compared with the 1-m spacing). To determine the advantages and disadvantages of each spacing requires further monitoring in the next phase.

The better performance of the outer rows compared with the centre row (when the hedge is being established) is probably due to increased availability of moisture, sunlight, and nutrients close to the hedgerows. Therefore, it may be advantageous to increase the maize population near the hedges during the first cropping season and use this improved microenvironment to minimize losses. Care should be taken, however, that the added competition to the seedlings should not seriously hamper their growth. Part of the additional soil moisture in the hedgerow zones may disappear when hedges are established through direct seeding rather than seedlings (this requires less land preparation, resulting in less infiltration).

In summary, two aspects deserve special attention; both have an important bearing on the feasibility of the alley cropping system.

- The losses in crop production during the development period of the hedges are less than anticipated, making the system more attractive to farmers.
- The development period of the hedges was longer than expected, making the system less attractive to farmers; however, experimentation elsewhere in the District has shown that quicker results can be obtained.

References


