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

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

Editors: B.T. Kang and L. Reynolds

Jointly organized by the International Institute of Tropical Agriculture, Ibadan, Nigeria, and the International Live Stock Centre for Africa, Addis Ababa, Ethiopia

Supported by the International Development Research Centre, Ottawa, Ont., Canada, and the United States Agency for International Development, Washington, DC, USA

/Cultivation systems/, /agricultural production/, /humid zone/, /tropical zone/, /Africa/ — /agricultural productivity/, /Leguminosae/, /soil fertility/, /agroforestry/, /on-farm research/, /nitrogen fixation/, /intercropping/, /forage/, /conference reports/, /recommendations/, /lists of participants/.


Technical editor: W.M. Carman

A microfiche edition is available.

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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 entresueros 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 entresuero 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 entresuero. Este libro revisa la situación actual de la investigación sobre la agricultura de pasillo o de entresuero 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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On-farm research methods for alley cropping

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Abstract — On-farm research methods, which follow a sequence of events until the technology is ready for adoption by farmers, can be applied in alley cropping research and development. Well-focused, on-farm research consists of sharply defined objectives, criteria for site selection, identification of target groups, accurate descriptions of the farming system, constraints and opportunities, appropriate design of on-farm trials, and a well-established, on-farm testing program. As a composite technology, alley cropping needs to be tested under real farm conditions. On-farm trials can be researcher managed or farmer managed, depending on the complexity of the technology and to what extent the technology has been tested under farmers' field conditions. Researcher-managed trials are usually conducted in the early stages of alley farming research and provide information mainly of a biological nature. Farmer-managed trials usually give indications of both the biological and socioeconomic aspects of alley cropping applications.

Introduction

Before any new technology is adopted by farmers it must be tested under real-farm conditions. The final test for the success of a new technology or innovation is adoption by a large number of farmers in a target area. On-farm research (OFR) can effectively show whether a technology can be transferred and adopted by farmers or whether modifications are required. Through OFR, new and improved farming methods are continuously being tested and evaluated by researchers in collaboration with farmers. Like any other new technology, alley cropping must be tested through OFR. As a new technology, it must be technically and economically feasible and superior to the existing technologies it is designed to replace. This paper generally describes OFR methods and how they can be used to conduct on-farm trials for alley cropping. Because the Farming Systems Programme of the International Institute of Tropical Agriculture (IITA) has only recently begun OFR on alley cropping, discussion in this paper deals mainly with methods and guidelines rather than with results.
Components of on-farm research

Site selection

A research site should represent land types or production environments that occur extensively in target areas. The site may be divided into "recommendation domains." A "recommendation domain" is a set of farmers who cultivate land with similar features and who have access to similar resources (Tripp 1982). For example, in the derived savanna of southwestern Nigeria, two recommendation domains can be distinguished: farmers who cultivate the forest and savanna fields and farmers who cultivate only the savanna fields. The second recommendation domain has shorter fallow periods (Palada et al. 1985). For both groups, alley cropping is feasible; however, the benefits and impact may differ.

Other criteria are important when selecting a research site: farm size; major cropping or farming systems and potential for improvement; and infrastructure quality (i.e., roads, markets, transportation, credit, farm inputs, and accessibility). The selection of sites for alley cropping trials should consider land type (upland, lowland); soil (fertility, depth, texture, pH, organic matter); topography and slope; climate (rainfall); agronomic and socioeconomic factors; and the farming system (permanent, semipermanent, bush fallow). The researchers should ensure that the sites selected conform with the definition of the target groups and land types.

Ngambeki and Wilson (1984) used the following six criteria to select a site for their alley cropping trial: yam–maize producing area; size of the active farming community; shortage of staking material; soil fertility problems; quality of marketing facilities for yam and maize; and accessibility.

Site description

After the research site is selected, the research team should describe the area’s existing farming systems, normally through an informal exploratory or diagnostic survey that may last 1 or 2 weeks. Preliminary information is collected before the survey starts. This preliminary information forms the basis for determining what data should be collected.

The exploratory survey provides a description of the area’s farming systems and identifies target groups of farmers. It also tries to identify the major constraints operating in the systems and the farmers' goals and aspirations. This information is then used to design appropriate interventions to the system (Mutsaers et al. 1986).

The survey team should include as many relevant disciplines as are available; in most cases, however, the minimum size of the team is two— an agronomist and a social scientist. In areas where constraints are related to soil problems and livestock, these disciplines will be included in the survey team. These four disciplines should be represented in on-farm research in alley farming.

The following areas should be included in the survey information: physical environment; field history, particularly the length of the fallow period; cropping techniques, with particular reference to soil fertility maintenance; postharvest practices such as utilization of crops, crop residues, and by-products; livestock systems, including species, feeding regimes, and interaction with cropping systems;
socioeconomic aspects, including access to land and tenurial arrangements, sources, and distribution of labour, peak and slack periods and bottlenecks, and sources and principal uses of cash and credit. A knowledge of external support structures such as the availability of extension and input delivery systems is also useful.

Alley farming may have a higher chance of being accepted in areas with soils of low fertility (Wilson and Kang 1981; Kang et al. 1984), a sloping topography (Parera, this volume), with livestock as a component of the farming systems (Ngambeki and Wilson 1984; Atta-Krah 1985), and where farmers are landowners (Francis, this volume).

In an exploratory survey of two villages in the derived savanna near IITA, inherent low fertility of soils in the area is one of the major technical constraints (Palada et al. 1985). This was observed in both savanna and forest fields where the dominant soils are highly eroded and sandy, with shallow top soil and low organic matter. The team proposed two interventions for soil fertility improvement and maintenance. Alley cropping was proposed as a long-term solution with the use of fertilizer recommended as a short-term solution. The major cropping system in this area is a maize and cassava intercrop.

Design of on-farm trials

The design of on-farm trials for alley cropping should be based on the major problems and constraints observed during field visits, surveys, and farmer interviews. The trial must be directed at a specific problem with well-defined objectives. They should test interventions designed to solve previously identified constraints and evaluate the suitability and feasibility of the proposed solution. Suggested guidelines for developing and designing on-farm trials should include reasonable gains in yield acceptable to farmers. It should prove beneficial to soil and environment, fit the farmer's resources (capital, labour, land, cash, and management), be adapted to the site's physical and biological conditions, be stable over time and fit in with other management practices, be simple enough to be understood, and be socially acceptable (Zandstra et al. 1981).

An example of the on-farm trial design for alley cropping in the Alabata/Ijaiye pilot area near Ibadan is presented here. The specific objectives of this trial are to determine the agronomic and economic feasibility of alley cropping under field conditions; to establish field crops of maize and cassava between alleys of woody shrubs and determine yields and productivity; to monitor soil fertility changes over time in plots with alleys compared with natural fallow; and to determine the length of cropping and fallow periods.

There are two treatments: first, maize and cassava (farmer’s system, no alleys) and, second, maize and cassava with Leucaena alleys at the recommended spacing of 4 m. The first treatment serves as a control. Farmers establish maize and cassava using traditional methods. In the experimental treatment, farmers establish hedgerows of woody shrubs and grow food crops (maize + cassava) between the alleys using their own varieties and management practices. The only intervention to the farmer’s existing system is the introduction of woody shrubs. Each block contains the two treatments and represents one farmer and one replication. A
minimum plot size of 1,000 m²/treatment is required for the collection of economic data.

Selecting an appropriate design for on-farm experimentation can be difficult because of variability between fields. The physical and socioeconomic environment of the research area may also place constraints on the design of the trial. Therefore, in on-farm trials, careful selection of design to minimize variability and reduce experimental error is important. Some points to consider in designing on-farm experiments are the heterogeneity of many fields with respect to slope, drainage, fertility, and previous cropping systems; the small size of many farms and the need for large plots for farmer-managed tests; the limited capability of randomizing treatments; a limited number of plots in a single farm; and differences in management practices for a single crop.

Simple experimental designs for on-station trials may be used for on-farm trials. The specific design to be used will vary according to the complexity of the experiments. Trials involving one or two levels using basic field designs are recommended as a first step. As the research team becomes more experienced, the number of factors and levels can be increased. The most common experimental designs used for on-farm trials are the randomized complete block, randomized incomplete block, and factorial designs.

On-farm testing

After appropriate trials have been designed and planned, the research team should organize a field-testing strategy. Before this, however, testing farmers should be taught how to execute and manage the trial. It should be made clear to them that the trials are experiments, not demonstrations. Therefore, they should be aware that experiments are sometimes subject to the same failure as their own crops. Failure because of weakness in design or management should be discussed between researchers and farmers so that corrections and modifications can be made in the early stages of the research process. When failure is due to the effects of the treatment, the farmer should be compensated either in kind or cash.

Technologies for on-farm testing

A technology is any factor or a combination of factors employed in crop production to improve the farming system's productivity. Examples of technologies include cropping techniques, use of chemicals, implements, and new crop varieties. For on-farm testing, there are three technology classes: single component or elementary, composite, and package (Mutsaers 1984).

Single-component technologies cannot be broken down into separate elements. They can be applied without requiring additional changes in the farming system. Examples of single-component technologies are a disease-resistant plant variety or fertilizer application. In single-component technology trials, new technologies are compared with the farmer's own in an otherwise unchanged system. Such technologies are based on the assumption that improvements are possible in an existing system, without changing the whole system drastically. Such trials may be particularly useful at the start of an on-farm research program, when the researchers have insufficient knowledge of the system to venture into more complex technologies or packages.
Composite technologies are made up of several interdependent elements that cannot be considered in isolation. An example is alley cropping, which consists of the following elements: tree establishment and management, mulching to maintain and improve soil fertility and crop production, soil conservation, animal feed, and socioeconomic considerations. These elements are closely interrelated: if one element is missing, the benefit expected from the technology is not achieved. For example, in alley farming, the trees must be pruned to provide mulch and fodder. Use of prunings for fodder reduces the quantity available for mulch and, hence, adversely affects crop yields. Extending pruning intervals will result in more tree foliage for forage, but increased shading will be detrimental to crop production.

Package technologies are a combination of several technologies. Each or part of the elements in the package may have its own effect, but the elements may be combined to exploit a synergistic effect. The conventional “improved production packages” for single crops that have been produced extensively by experiment stations fall into this class.

The simplest package trials are those that test a combination of component technologies imposed on an existing cropping system or pattern. In a maize-cassava intercropping system, this could be mutually compatible improved maize and cassava varieties at a recommended plant arrangement with fertilizer and herbicides. The package is compared with the farmers' maize and cassava system. Additional treatments can be included in an “add-on trial,” which allows the added effect of each additional set of technologies to be assessed.

Researcher-managed trials

Researcher-managed trials are used to evaluate the performance of new technologies or a specific management component and to determine the optimum rates or level of available technologies in farmers' fields. These trials provide close control and a high degree of accuracy by reducing variability and are managed and executed by the researcher. The farmer is minimally involved.

On-farm trials managed by researchers can be exploratory, site specific, confined to a region, or located in several places (Hildebrand and Poey 1985). Researcher-managed trials will, however, provide less information on the acceptability of the intervention to the rural community.

Exploratory trials are used when little is known about an area or possible effects of a specific type of technology. They can be considered complementary to, or part of, characterization, and usually precede site-specific or regional trials. Exploratory trials normally provide more qualitative than quantitative information about several factors. Frequently, two levels of each factor are included and few replications are used. The most common designs are the 2^n factorial and plus or minus trials. An exploratory trial can sometimes be superimposed on farmers' fields without special preparation of the experimental area. Exploratory trials are similar to on-station trials in terms of design; however, they are conducted on farmer's fields.

A good example of an exploratory trial with alley cropping is the introduction of woody species in an area where the species have not been grown before to determine their compatibility with annual food crops grown in the alleys. The woody species can be superimposed on the existing cropping pattern of the farm.
Site-specific trials are often designed to search for potential or maximum effect of a technology. Experimental cultivars, for example, are frequently screened under conditions that do not limit the expression of genetic potential. This potential, however, is measured only for the one location — the experiment station. To obtain more useful information, two or more farm locations can be used with the same type of experimental design and analysis to measure independently “deviations from potential” at different locations. Analysis of data from site-specific trials is similar to that of yield gap analysis (see Gomez and Gomez 1984).

Because they are usually complex, with a relatively large number of treatments and replications, site-specific trials are only conducted in a limited number of locations. Information sought is agronomic and not socioeconomic, so plots are small. Possible sources of variation, such as soil fertility, are frequently controlled at the same levels used on the research station. Participation of the farmer is minimal.

An example of a site-specific, researcher-managed trial is that of alley cropping with *Leucaena* and *Gliricidia* in the derived savanna of southwestern Nigeria. This trial is designed to demonstrate the potential of alley cropping in regenerating soil fertility and control of a persistent weed, *Imperata cylindrica*, which are specific problems in the area. Three treatments are used: maize-cowpea, maize-cowpea with *Leucaena*, and maize-cowpea with *Gliricidia*. The maize-cowpea treatment serves as a check plot (no alley). The trial can be set up in a randomized complete block with two locations as replications.

Regional trials consist of a set of similar trials conducted in a region previously identified as a recommendation domain. Their main objective is the evaluation of data from on-farm and on-station trials to define the interaction of technology with environmental conditions, from both agronomic and economic viewpoints. Regional trials may result in confirming the homogeneity of a targeted area or suggest that, to be relevant, the area be divided. Recommendations for treatments for farmer-managed trials should result from the analysis and interpretation of regional trials. Regional, on-farm trials in alley cropping in Nigeria are a good representation of this type of researcher-managed trial. In each of the humid and subhumid zones of Nigeria, trials are being conducted in 6–10 locations by IITA and the International Livestock Centre for Africa (ILCA) in collaboration with national institutions.

Farmer-managed trials

Farmer-managed trials provide the opportunity for the farmers to manage and evaluate one or two promising treatments from regional trials. It is only at this stage that the acceptability of an intervention can be determined. Large unreplicated plots of at least 1 000 m² should be used. This enables the farmers and researchers to compare the treatments with their own practices. A check plot with these practices can be included in the design. In practice, the check plot serves the researchers more than the farmers. If researchers wish to measure the results of the farmers’ practices, they can also sample the farmers’ fields. However, agronomic data (e.g., plant density and yield) and economic data (labour use, costs, and returns) of the farmers’ practices must be kept. It is desirable to have at least 30 farmers in these trials in a recommendation domain. A team composed of an agronomist, a socioeconomist, and two research technicians is sufficient to handle data collection from 30 farmers.
Data collection, monitoring, and evaluation

The long-term purpose of monitoring and evaluation is the better understanding of how innovations perform in farmers' fields under farmer management and whether the innovations are acceptable or, with modification, can be made acceptable to farmers. Monitoring and evaluation can also identify problem areas related to technology and provide feedback to on-station researchers for the refinement of the technology. Data are needed each year for the annual design exercise, when the research team decides which trials should continue, which should be dropped, and whether the design or operational procedures of each trial should be modified.

Good monitoring and evaluation include accurate descriptions of cooperating farmers and their fields; exact monitoring of field operations by enumerators under close supervision; informal farmer interviews by the researchers; and closed sequence questionnaires administered at the end of the season to farmers by supervised enumerators. In on-farm research, four types of data are usually collected: physical (including climate and soil), agronomic performance of crops or technology, economic performance of crops or technology, and social acceptability.

Physical data

Data on rainfall are collected daily and reported on a weekly basis. Other climatic data such as solar radiation, temperature, and evaporation can be monitored from the nearest weather station. For each plot where a trial is established, data on land type and soil characteristics should also be collected. At the end of the cropping year, the data are summarized and analyzed to evaluate crop performance, cropping systems, or a technology.

Agronomic data

There is a wide range of agronomic data that can be collected from trial plots and farmers' plots. The research team should decide which information is necessary and plan the data-collection process accordingly. Data collection requires frequent visits to trials and careful observation; it is, therefore, essential to identify the important points for each trial. In alley cropping trials, data such as hedgerow establishment, height, biomass production from prunings of woody species, and regrowth are as important as yield data from annual food crops grown in the alleys. Where prunings are removed for animal food, the quantity must be measured. It is important to prepare a field book for agronomic data; this book should contain all information about the trial, soil, crop, and field operations.

Economic data

Two sets of economic data are usually collected. The first set concerns only those plots where the trials are established. These trials may consist of two or more fairly large (1 000 m²) treatments to get reliable labour data. The other set of data is gathered from the farmers' untreated plots. These data are useful for farm model studies. In the first set of data, partial budgeting and simple cost and returns analyses are used to evaluate the technology's economic performance. An example of the economic evaluation of alley cropping is reported by Ngambeki (1985).
Social acceptability

The ultimate test of social acceptability of an intervention is its adoption rate. Many factors come into play to determine acceptability. Successful on-station trials may not be adopted by farmers, who may have different opinions on what are positive changes. Interventions that are successful under one social system may fail under another. Trials managed and executed by farmers are essential to test acceptability (see Atta-Krah and Francis, this volume).

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