The management of upland soils (IBSRAM/*AFRICALAND*)

Network Document no. 17

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Report of the Annual Meeting of the *AFRICALAND* Upland Soils Network

on

The Management of Upland Soils (IBSRAM/*AFRICALAND*)

Yaoundé, Cameroon
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Preface

The annual meeting of IBSRAM's *AFRICALAND* network took place from 15-21 May in Yaoundé, Cameroon. It was the first meeting of the new *AFRICALAND* Management of Upland Soils network which was formed after the 1994 annual meeting in Abidjan by the amalgamation of the acid soils and the land development networks. Nineteen national scientists and resource persons from IITA, ICRAF, and the universities of Hamburg and Bayreuth (Germany) took part.

The meeting had two main objectives: to bring together all participating scientists to discuss the progress achieved during the past year, and to plan future activities of the projects and the network.

During the first part of the meeting, the technical progress reports of the network projects were presented by the national collaborators. According to the stage of progress of the projects, different aspects and problems of implementation were highlighted. Some projects were just beginning to yield the first set of data, while others were already able to present the results of several years' of research.

The second part of the workshop was devoted to discussion and planning of future activities within the network. Emphasis was placed on the three new projects in the network - in Côte d'Ivoire, Ghana, and Cameroon. On the basis of site characterizations, socioeconomic baseline studies, and participatory rural appraisals, project proposals were presented by the national collaborators of these three countries. These proposals were discussed in depth by all participants of the meeting. In a joint planning workshop, detailed experimental designs for the new projects were finalized.

These proceedings contain the annual reports of the network projects, a summary of the new projects in Côte d'Ivoire, Ghana, and Cameroon, and materials related to the planning proposals for the future activities of the network. The programme of the meeting is given in Appendix I, and the participants of the meeting are listed in Appendix VIII.

Network overview

Michael A. Zöbisch*

The amalgamation of two *AFRICALAND* networks

After the annual network meeting in Abidjan (Côte d'Ivoire) in April 1994, the two former *AFRICALAND* research networks, the acid soils network and the land development network, were amalgamated into a single network - the Management of Upland Soils network.

The two original networks had been established at different times and with different objectives. The acid soils network concentrated on the effects of soil acidity and aluminium toxicity on soil fertility, while the land development network focused on problems related to the effects of land clearing and postclearing soil tillage on soil physical properties and soil productivity.

Experience over the years showed a high degree of overlap between the two networks. On many sites, the experiments of the land development network were also located on acid soils. In both networks, crop rotations, residue management and soil tillage were important components of the experiments. In Cameroon and Côte d'Ivoire, the experimental sites of the networks were actually located adjacent to each other. Overall, the networks had more common features than dissimilarities.

Also, experience from both networks revealed a strong need for a more holistic approach to soil management, and more integrative work of the scientists involved. To facilitate these aims, the Management of Upland Soils Network was established as a single entity.

The Management of Upland Soils network

Currently, the network is made up of twelve projects in seven countries which are administered by eight national institutions (NARS) (Table 1). For Côte d'Ivoire, Ghana, and Cameroon, new projects were started which are funded by the German Government through GTZ.

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Table 1. Countries, NARS and Projects involved in the *AFRICALAND* Research Network.

Country	NARS		Project Title	Stage of progress
Côte d'Ivoire	Institut de Forêts, Abidjan	-	Identification of methods to manage acid soils for sustained food production in central-south Côte d'Ivoire	In progress
		-	Land clearing and postclearing soil management in central-south Côte d'Ivoire	Current phase completed
		-	Sustainable agriculture for humid tropical Africa - linking environmetal and productivity concerns in Côte d'Ivoire	Started
Ghana	University of Science and Technology (UST), Kumasi	-	Sustainable agriculture for humid tropical Africa - linking environmetal and productivity concerns in Ghana	Started
Nigeria	University of Ibadan, Ibadan	-	Land clearing and postclearing soil management for sustainable crop production in Nigeria	In progress
	Obafemi Awolowo University, Ile Ife	-	Management of Nigerian acid soils for optimum productivity	Current phase completed
Cameroon	Institut de Recherche Agronomique, Yaoundé	-	Management and improvement of acid soils for sustainable agriculture in central Cameroon	In progress
		-	Land clearing and postclearing management of acid soils in forested areas of central Cameroon	Current phase completed
		-	Sustainable agriculture for humid tropical Africa - linking environmetal and productivity concerns in Cameroon	Started
Congo	Centre de Recherche Agronomique, Loudima	-	The management of acid soils for cassava-based cropping systems in the Niari Valley, Congo	Current phase completed
Uganda	Makerere University, Kampala	-	Land clearing and soil management for sustainable food production in the high-rainfall zone around Lake Victoria, Uganda	Current phase completed

Table 1. cont'd.

Country	NARS	Project Title	Stage of Progress
Zambia	Misamfu Regional Research Centre, Kasama	Evaluation of some soil-crop management systems for sustainable crop production and environmental protection	Current phase completed

Network structure and activities

The *AFRICALAND* Management of Upland Soils network is a structured entity of individual research projects based on a common network hypothesis and following a common overall network objective. Individual projects are defined within this structure. However, these projects exhibit their own distinct project objectives, geared to the specific conditions of their locality. All network projects are set within a network frame (Figure 1) which clearly depicts their role within the network. The flow of information, the interaction between the projects and IBSRAM, network analysis, and the regular revision of research programmes are designed to ensure coherence and continuity in order to achieve the network's objectives.

One of the main contributions of IBSRAM to the network is the provision of technical backstopping, and eventually the pooling and synthesis of research results. The results will be used to develop packages for validation in other, similar resource management domains, and not only within the participating countries. Therefore, the exchange of ideas and experience between the participating scientists, the national institutions, and IBSRAM are key elements of the network. These are facilitated by a regular exchange of information between the projects and IBSRAM.

Annual meetings for the network are organized to review and discuss the progress of the individual country projects. At these annual meetings, the network as a whole is evaluated and necessary adjustments are made. Resource persons are invited to these meetings to address particular problem areas and to advise and assist the individual projects and the network.

Network hypothesis

The experience from previous research clearly indicates a need for nutrient input to achieve and maintain sustainable levels of yields. This entails aspects of nutrient input as well as nutrient cycling, the efficiency of nutrient uptake by plants or plant associations, and the reduction of nutrient losses. Concerning nutrient input, the main

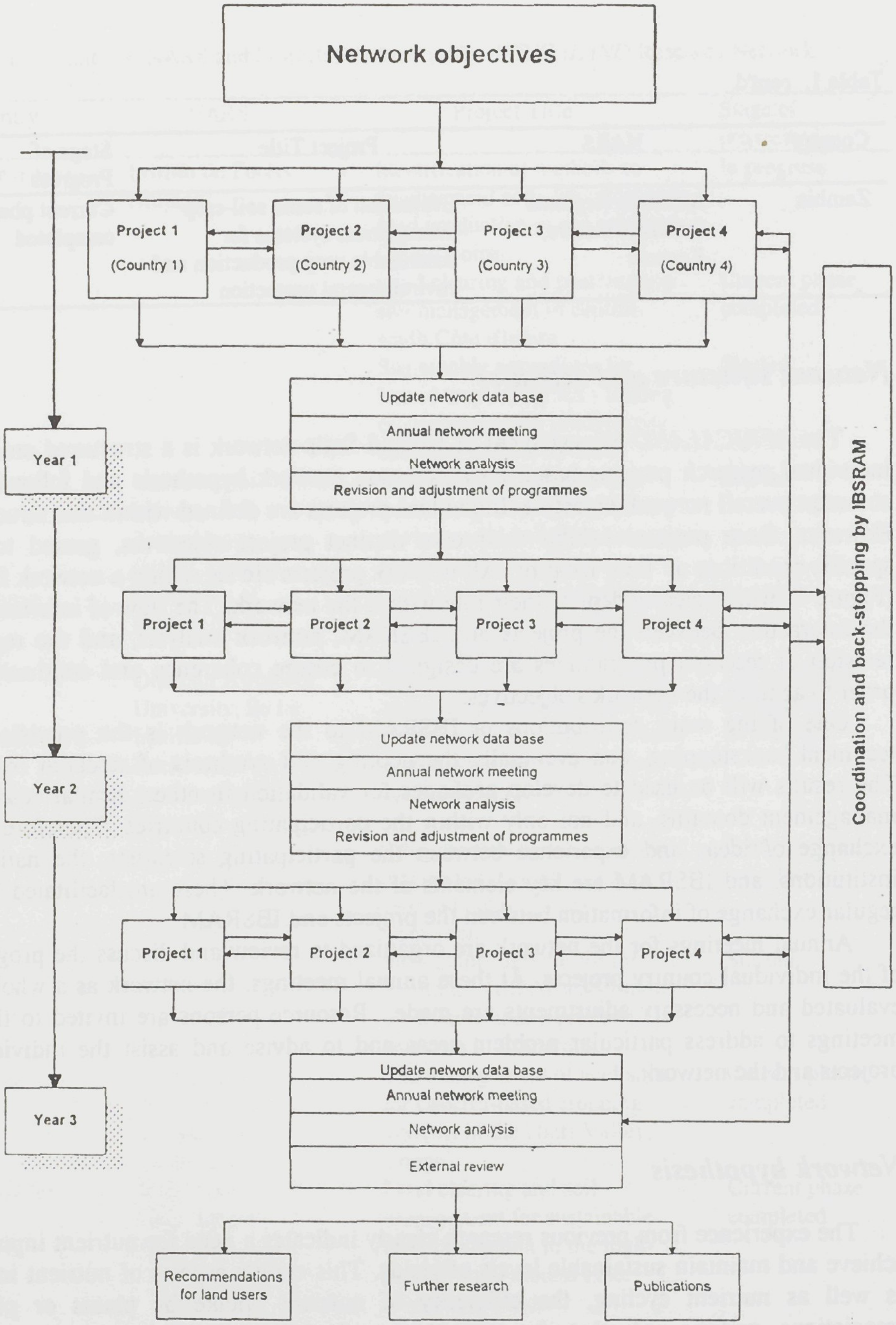

Figure 1. Research network frame.

question arising is how little and in which form nutrients are required to achieve and maintain sustainability at current yield levels, and how can external inputs be optimized and adapted for different cropping systems and expected yield levels.

There are also important interactions between soil moisture, nutrient transport within the soil, and nutrient uptake by plants. Soil moisture limitations during critical stages of plant development can have significant effects and influences on crop performance. The competition of weeds for nutrients, soil moisture, and light are other important issues which need to be addressed.

These interactions can have positive as well as negative implications. It is therefore important to optimize them in a positive direction for the efficient use of both nutrients and moisture. Practices addressing these issues are thus key elements for soil management in smallholder agriculture, including nutrient input from fertilizers and residues, and tillage for soil moisture management and weed control. These 'guiding forces' have led to the development of the following network hypothesis:

> *'Through the development and implementation of appropriate soil, water, and nutrient management practices, sustainable agricultural productivity can be achieved on the upland soils of humid and subhumid tropical Africa.'*

Network objectives

The network objectives are based on a regional perspective and extend beyond the scope of the individual country projects. They are primarily concerned with issues related to facilitation, guidance, networking, and harmonization. The objectives also encompass activities and achievements of the individual country projects. They are therefore, to a considerable degree, linked to and dependent on the individual project objectives and the extent of their eventual accomplishment.

Overall network objective

To develop and evaluate improved, alternative soil management options which are technically sound, environmentally appropriate, economically viable, able to reduce production risks, and acceptable to small-scale farmers - and which will lead to sustainable cropping.

Specific network objectives

- To assess and evaluate the needs of farmers as they relate to improved and appropriate soil management practices.
- To evaluate and assess the performance of improved cropping practices, and appropriate soil, nutrient, and moisture management methods, and their effects on sustained soil productivity.
- To establish soil management packages for the control of soil acidity and for soil-fertility enhancement to ensure sustained soil productivity in permanent cultivation systems.
- To train cooperating scientists within the framework of the research, and to disseminate relevant technical information with a view to strengthening the NARS.
- To initiate investigations into the acceptability of recommended technologies resulting from the research.
- To assess the sustainability of improved, alternative soil management practices through the selection and use of appropriate indicators.

Network steering committee

To facilitate participation of the national projects in the networks' management and future planning and to enhance the flow of information, a network steering committee was launched during the annual meeting. The terms of reference of the steering committee are given in Appendix II.

On-farm research

A new component of all new projects will be on-farm research. These experiments are expected to supplement process-related data from experiment stations. Investigations carried out under farmers' conditions will give less precise but more realistic results than on-station experiments, especially in terms of yield and total biomass production.
Emphasis will be placed on soil management 'packages' which will be tested in their entirety. On-farm research will be used to test single packages and individual practices (i.e. parts of packages) considered to be beneficial to the farmer. The selection of the practices or packages will be made by the farmer. He (or she) will be solely in charge of the management of the trial. The researcher's role will be limited to close monitoring of the farmers' activities related to the trials and measuring inputs and yields.

The acceptability of measures and packages will largely depend on their economic benefit to the farmer. Therefore, the collection of economic data will be related to the practices and packages chosen by the farmer, and the monitoring of the farm's economy as a whole will form a major part of this type of research. Another important aspect of farmer-managed on-farm research is the demonstration effect which it will have on other farmers.

Quality-assurance programme

To be able to synchronize the results from the projects, it is necessary to harmonize the methods and procedures used for soil and plant sampling and analyses within the network. A quality-assurance programme has therefore been established. With assistance from the University of Kassel (Germany), methods appropriate for the conditions of the network will be identified. The objectives and planned activities of the programme are detailed in Appendix III. As a measure of accuracy, standard soil and plant samples will be exchanged between the laboratories and analyzed regularly. The quality-assurance programme will work out recommendations for the improvement of laboratory facilities, and identify training requirements for laboratory staff. The programme started at the beginning of the year. Regular feedback is expected from the annual network meetings.

Participatory rural appraisals

Farmers' views and attitudes and their knowledge and experience are essential in formulating farming activities. The adoption of new soil management technologies depend on their appropriateness to the farmers. Therefore, the applied and adaptive research of the network is planned with the participation of the farmers themselves. If issues critical to adoption can be identified before the research programme begins, the chances of success are higher. The new projects within the network will use participatory rural appraisals (PRAs) as a diagnostic survey tool and as a people-oriented approach for planning research projects. The PRAs are carried out within the farming communities participating in the on-farm research of the network. The techniques applied to gather, structure, verify, and analyze information during the PRAs are individual household interviews, cross-checking from different sources, sampling quantitative and qualitative data (e.g. soils, plants, etc), group interviews, direct observations at site level, and the use of secondary data sources (e.g. statistics, reports, maps, etc).

The PRAs are carried out by interdisciplinary teams of the NARS. The final design of the experiments and treatment selection will largely depend on the outcome of the PRAs in the network projects. The most significant contributions are expected from the farming communities themselves.

Training programmes in PRA methods were carried out for the new network projects in Côte d'Ivoire, Ghana and Cameroon. The first PRA studies of farming communities in these countries provided a valuable input for the planning of our new network experiments. Details of the PRA methods used, the PRA training and first results of the PRA studies are given in Appendix IV.

Planning of new network projects

Within the framework and regional setting of the network, the individual country projects will focus their work on problems typical of their location. Although the general nature of smallholder agriculture in the region and its problems and constraints are well recognized and understood, local peculiarities and needs will have to be taken into consideration. It is a clear aim of the network to incorporate farmers' views into the design of experiments, especially for the on-farm trials. Therefore socioeconomic surveys and participatory rural appraisals (PRAs) are firm diagnostic elements of the network's country projects. Through these, the land users' problems and constraints will be fully recognized and understood by the researchers. Appropriate detailed research can then be designed to meet the farmers' needs.

Following the network's objectives, three projects (in Côte d'Ivoire, Ghana, and Cameroon) were planned in a joint planning workshop involving scientists from all network projects. Experiments for both on-station and on-farm research were designed in accordance with the physical site characterizations and the PRA studies which were carried out by the national teams. The national projects also agreed on methods of sampling and laboratory analysis in order to improve the overall quality of data. A summary of the project planning documents for the three new projects is given in Appendix V.

An overview of the conditions at the new project sites is given below.

Côte d'Ivoire. The project in Côte d'Ivoire will have two sites, i.e. Bécédi (approximately 70 km west of Abidjan) and Abengourou (approximately 100 km northeast of Abidjan). Both sites are located in the humid forest zone of southern Côte d'Ivoire on slightly undulating terrain. The annual rainfall is around 1500 mm distributed over two rainy seasons (April to July and September to November).

The major soils of the area are Haplic Acrisols. The soils are moderately acid with moderate to high contents of organic matter when under forest. The cation-exchange capacity (CEC) and base saturation are low, and the soils are highly leached and acid. The general fertility status of these soils is low. Under cultivation, the organic-matter content decreases significantly.

At both sites (Bécédi and Abengourou) the land use of the small-scale farmers is based on food crops, such as plantain, cassava, yam, and maize. Interplanting is practiced frequently. To some extent, plantation crops are grown, e.g. coffee and cocoa in Abengourou, and coffee, cocoa, oil palm, rubber, and cola nut in Bécédi. Pressure on the land has caused a reduction in fallow periods. Hence, the soils tend to be overexploited and quickly lose their fertility if no fertilizers are applied. The increased and intensified utilization of the soil requires alternative management techniques which will enable the small-scale farmers in the area to secure sustainable levels of return from their land.

Ghana. The project area is located in the central part of the Ashanti region. It is situated in the deciduous forest zone with a bimodal rainfall distribution and a mean annual rainfall of approximately 1500 mm. Mean annual relative humidity is around 62%; mean annual maximum and minimum temperatures are 30.6 and 21.1 $^{\circ}$C.

The dominant soils of the area are Acrisols, Nitisols, and Ferric Lixisols. The soils have predominantly sandy to loamy textures. Many soils contain abundant gravel or concretionary materials which significantly affect their physical properties, particularly their water-holding capacity. The soils have a low inherent fertility, they are highly leached, have a low cation-exchange capacity, and low contents of organic-matter.

Eighty-five percent of the farming community are small-scale farmers with less than 2 ha of arable land. They use traditional labour-intensive methods of cultivation. The main food crops grown are tuber crops (i.e., cassava, yam, and cocoyam), plantain, and maize.

The present traditional land-use practices in the region are based on shifting cultivation with fallow periods reduced to 1 - 2 years. These systems have not been able to sustain soil productivity under intensive cropping. Therefore the current strategy to maintain food security is mainly based on area expansion using existing technology and to a much lower degree on the use of improved varieties and crop-protection measures. Subsidized fertilizers are no longer available and hence yields are declining gradually, because farmers cannot afford the high cost of fertilizers.

There is an urgent need to develop appropriate soil management options which are able to maintain soil fertility and sustain crop yields at levels acceptable to small-scale farmers. Soil management options able to support sustainable crop production will have to rely on affordable resources and technologies. The fundamental considerations in achieving improved appropriate soil management are organic matter (e.g. crop residues, manure, mulches), soil and moisture conservation, and suitable crop rotations and combinations.

Cameroon. The project area is located on and around Minkoameyos research station, approximately 10 km west of Yaoundé in the central forest zone of Cameroon. The area lies at an altitude range of 600-800 m asl. The climate is characterized by an even temperature regime with a mean annual temperature of 23.5 $^{\circ}$C and a mean relative humidity of 80%. The rainfall pattern is bimodal, with rainy seasons from March-June and from September-November. The mean annual precipitation is about 1600 mm. The dominant soils of the forest zone are red Acrisols, which are significantly leached of clay. The clay content varies between 25% in the topsoil and 55% within and below the root zone. The soils are generally well structured and exhibit favourable draining characteristics. But they are generally poor in nutrients. The organic-matter content under forest is high, but decreases rapidly after cultivation. This is assumed to be due to the removal of the original dense vegetative cover, aggravated by the increased removal of plant nutrients by crops.

Farming practiced in the project area is typical for the region. The average farm size is approximately 5.5 ha, of which 3 ha are under cocoa, 2.25 ha are grown to food crops, and 0.25 ha are home gardens (i.e. fruit and vegetables). The major cropping systems in food crop production are cassava- groundnut- and plantain-based systems using mixed cropping and intercropping techniques. Fertility decline after clearing is significant. Therefore it is a common practice to farm the land for one year only after clearing, before returning it to fallow for a period of 5-10 years. However, due to increased pressure on the land, these fallow periods will be shortened in the future.

Small-scale farming exclusively depends on family hand labour, using handhoes for tillage and weeding, and machetes and axes for controlling bush growth and to cut small trees. For the clearing of fallow land from large trees, however, hired chainsaws are used by the farmers.

The main problem related to the soil is the rapid decline of soil fertility after only very short periods of cultivation, i.e. one year. This forces the farmers to clear more forestland than before. As a consequence, larger areas are being degraded at a faster rate, and the farmer is obliged to invest much more labour into land clearing for cultivation than before. There is an urgent need to identify and develop soil management options which will enable a more permanent and sustainable cropping of the land by using the resources which are available to and affordable by the farmer.

Collaboration with advanced country research institutions

A new dimension for the network is the development of scientific collaboration with advanced-country research institutions. Limited funds were set aside to initiate a scientific collaboration between the University of Bayreuth (Germany) and the *AFRICALAND* network project at the University of Science and Technology in Kumasi (Ghana). The aim is to develop institutional links through collaborative research conducted by way of students' theses, and addressing the current utilization, potential, and limitation of chicken manure in the area around Kumasi (Ghana). The study is planned for a period of six months field research and 6 months' data-processing and evaluation. Two Ghanaian and two German students will participate, and the study will begin in March 1996. This type of collaboration, if successful, may be extended to other network projects at a later stage.

As a further step to develop the potential for a networkwide collaboration with research institutions from advanced countries, a research topic was identified which would be of interest to other institutions and at the same time attract donor funding. Within the network, the management of biomass was identified as probably the most critical single component of soil management in smallholder farming areas of the humid tropics. Weeds, conventionally seen as competitors to crops, can play an important role in providing biomass and thus contribute significantly to the improvement of soil structure and nutrient cycling. There are several dimensions to the topic which make it interesting and challenging for interdisciplinary research. Besides soil and crop interactions, cultural and socioeconomic factors play an important role in the management of biomass at the farm level. The topic is expected to address an important common issue throughout the network. An outline proposal was formulated which could eventually be developed into a full-scale project proposal for presentation to donors (Appendix VI).

Feedback from farmers

In Uganda, farmers have been involved actively in research from the start of the project. Farmers' days were organized regularly and farmers frequently consulted the researchers for advice. This shows that the research activities were of immediate practical relevance to the farmers' problems and not merely of scientific interest. In Appendix VII, Mr. Kasule, a farmer from Uganda, gives a brief account of his experience with the *AFRICALAND* research project in his country.

It is hoped that by introducing on-farm research and PRAs into the network, farmers will be more involved in the research process as a whole, from planning through implementation to the development of methods and technologies to increase the chances of adoption.

Opening address

Adoum Gargoum*

*Monsieur le Directeur de Recherche du Conseil International pour la Recherche sur les Sols et leur Gestion (IBSRAM), Monsieur le Coordonnateur du Réseau IBSRAM "*AFRICALAND *Management of Upland Soils", Monsieur le Représentant du Directeur de l'IRA, Honorables invités, Mesdames, Messieurs:*

Il m'est particulièrement agréable de présider aujourd'hui, à la cérémonie d'ouverture de la Huitième Réunion Annuelle des Réseaux Africains IBSRAM, au nom de S.E. Monsieur le Ministre de la Recherche Scientifique et Technique.

Depuis l'annonce de sa tenue par les collaborateurs nationaux du réseau IBSRAM, à l'occasion de leur retour de la Septième Réunion du genre tenue à Adiopodoumé (Côte d'Ivoire) l'année dernière. il s'agit. vous vous en doutez, d'un évènement attendu au Cameroun. Soyez-y les bienvenus.

Le présent atelier n aurait pu se tenir sans les contributions de l'Institut de la Recherche Agronomique (IRA) et du Conseil International pour la Recherche sur les Sols et leur Gestion (IBSRAM). Qu'il me soit donc permis de leur présenter ici la profonde gratitude du Gouvernement.

C'est pour la deuxième fois que l'IBSRAM, en collaboration avec l'IRA, organise au Cameroun une réunion dans le cadre de ses réseaux africains. Déjà, en janvier 1986, une rencontre de ce genre s'était tenue à Douala. C'est ici le lieu de saluer le type de collaboration qui existe entre l'IBSRAM, et les institutions-hôtes en vue de conduire des programmes de recherche sur les sols. En effet, bien que financés entièrement par l'IBSRAM, les projets nationaux sont. dans leur totalité, conçus, dirigés et exécutés par des chercheurs nationaux. Cette formule, qui considère ces derniers comme des acteurs à part entière. déroge du modèle habituel où le chercheur des pays en voie de dév eloppement est considéré. au pire. comme de la simple main-d'oeuvre, au mieux comme un faire-valoir.

Cela dit. toute oeuvre humaine comporte des imperfections. et je m'en voudrais de terminer mon propos sans faire un bref rappel des maux qui minent les réseaux *AFRICALAND* et qui sont rapportés à suffisance dans le périodique *IBSRAM Newsletter*.

* Secretary General. Ministry of Scientific and Technical Research, Yaoundé, Cameroon.

Ainsi, contrairement aux réseaux des autres continents, les réseaux africains ont connu : (i) des changements fréquents de coordonateurs qui ont énormément gêné la marche normale du travail sur le terrain ; (ii) la fermeture de leur bureau régional qui a rendu les communications avec le/les coordonnateurs compliquées et chères et, plus près de nous ; (iii) le non-renouvellement des réseaux Sols Acides et Vertisols. Au fil des ans, tandis que les autres réseaux prennent de l'envergure et connaissent des prorogations, ceux implantés en Afrique se réduisent comme une peau de chagrin. Je crois en effet savoir que le réseau *AFRICALAND* ne comptera plus desormais que 3 pays au lieu de 10 qui y collaboraient auparavant. Ceci laisse cette impression désagréable ou après avoir démarré en fanfare divers projets. et redonné le goût de l'initiative aux scientifiques nationaux. l'IBSRAM est en train. doucement mais sûrement. d'abandonner l'Afrique. Nous refusons de croire cela.

En effet. contrairement à ce que pourrait suggérer ce rappel. je suis persuadé que ce sont plutôt des lendemains meilleurs qui atendent nos paysans. désormais collaborateurs volontaires du réseau. grâce au dynamisme de la recherche scientifique et technique, et grâce à la collaboration internationale qui. à travers une meilleure appréciation de la situation. ne se désolidarisera pas.

Pendant les six jours que vont durer vos travaux. le Cameroun espère compiler suffisamment d'enseignements pour lutter à moindre coûts contre l'épuisement des sols et ainsi. garantir non seulement le mieux-être de la masse paysanne. mais aussi protéger l'environnement. Et vous pouvez compter sur le Ministère de la Recherche Scientifique et Technique pour une attention soutenue à vos discussions et à vos résolutions.

Je délare ouverts les travaux de la Huitième Réunion Annuelle des Réseaux Africains IBSRAM.

Welcome address

Mr. Raphaël Ambassa-Kiki*

Secretary general of the Ministry of Scientific and Technical Research, Director of Research of IBSRAM, Coordinator of the AFRICALAND research networks, invited guests, colleagues, ladies and gentlemen:

First of all, on behalf of the organizers, I wish to welcome you all to this 8th annual meeting of the *AFRICALAND* networks. I also would like to express our sincere appreciation to you all for taking your time to make it to this gathering. We are particularly grateful to those who traveled over long distances for long hours to honour their rendezvous at this meeting.

Between our last gathering in Côte d Ivoire and today, I have no doubt that the networks have made substantial progress towards achieving our overall objectives, the result of which we hope to share with all present at this meeting. More importantly, we are looking forward to a solid and relevant strategy and workplan for the coming year that would strengthen and enhance our collective contribution to the new *AFRICALAND* Management of Upland Soils network in the future. I now call upon Dr.Syers, the Director of Research of IBSRAM to present his welcome address.

* National Collaborator, IRA/CRA, Cameroon.

Welcome address

J. Keith Syers*

Secretary general of the Ministry of Scientific and Technical Research, director general of IRA, distinguished guests, ladies and gentlemen:

On behalf of IBSRAM and its director general, Dr. Marc Latham, it is my pleasure to welcome you to this annual network meeting today. This is an important meeting because it involves reporting on and winding up the two previous research networks (the management of acid soils' network and the land development network) with reports on the national projects of both networks and on the GTZ project evaluation of the land development network. and also because it will determine project planning for the new Management of Upland Soils network.

IBSRAM is pleased that BMZ has agreed to the participation of Professor Horst Wiechmann (representing ATSAF) and Professor Wolfgang Zech (from Bayreuth University), in addition to the two members of the GTZ evaluation team - Dr. Michael Bosch and Dr. Jürgen Blanken. During this meeting it is intended to develop a special project involving three German universities and national projects. IBSRAM welcomes this activity because it provides underpinning strategic research, which is so vital to the success of the applied/adaptive research being conducted by the national projects in the network. There is also to be a new quality assurance programme for plant and soil analyses, which will be carried out with the assistance of the University of Kassel in Germany.

The hypothesis which underlies the new Management of Upland Soils network is as follows:

> *Through the development and implementation of appropriate soil, water, and nutrient management practices, sustainable agricultural productivity can be achieved on the upland soils of humid and subhumid tropical Africa.*

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* Director of Research, IBSRAM.

The concepts embodied in this hypothesis are particularly important and timely given the current level of interest in soil, water, and nutrient management research, and in sustainability.

We have a full and interesting programme, and I know that Mr. Ambassa-Kiki and Dr. Michael Zöbisch have been working hard to make it successful. We have several challenges to meet, and am confident that, with your full participation, we can achieve our objectives. I also hope that we can have fully open and transparent discussions so that we can share and correct any problems which we might have and move forward more successfully.

Once again, on behalf of IBSRAM, a very warm welcome and all good wishes for a productive and interesting meeting.

TECHNICAL PROGRESS REPORTS

Identification of methods to manage acid soils for sustained food production in central-south Côte d'Ivoire

G.H. Godo*

The experiments have yielded the first harvest of the 'validation phase'. No striking differences in soil characteristics betwen the treatments could be detected after this first year. There were practically no differences in yields between the low-input and the high-input treatments. For groundnut, however, differences in crop performance could be observed between the three cropping systems. In association with cassava, groundnut had the lowest yields (0.37 - 0.58 t ha^{-1}), whereas in rotation with maize, it showed the best results (1.15 - 1.20 t ha^{-1}). With the exception of groundnut, the overall yields of the experiments were clearly higher than the national average yield levels.

Site characteristics

The site is located in a secondary forest area in the south of Côte d'Ivoire, approximately 90 km west of Abidjan. The climate of the region is characterized by a bimodal distribution of rainfall, resulting in two dry seasons, i.e. December to March (long dry season) and August (short dry season). The average annual rainfall is around 1600 mm. The terrain is gently rolling to flat with maximum slopes of 20%. The soils are moderately acid shallow silty clays and silty sands, classified as gravelly Hyperisothermic Paleustults. The general fertility level is low.

Two traditional cropping systems are practiced in the area: (i) plantain in association with yam and a legume, and (ii) an association of cassava and maize. The cash crops grown in the area are coffee, cocoa, oil palm, and coconut. There is a tendency towards expansion of areas with cash crops and towards a reduction of areas cropped with food crops.

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Experimental design

The experiments were designed to test the long-term effects of different levels of external inputs with six typical cropping systems on soil productivity. They are now in their fifth year. After two years of an 'exploration phase', there was one year of cover-cropping with *Pueraria phaseoloides*. The experiments are now in their first year of the `validation phase'. For this phase, the treatments have been adjusted in the light of the experience gained during the exploration phase. Three different cropping systems are being investigated.

Traditional systems

Treatment A (**A**)	Yam intercropped with groundnut. N-P_2O_5-K_2O at a rate of 20-46-100 kg ha^{-1}; CaO depending on the exchangeable-Al content of the soil.
Treatment B (**B**)	Cassava intercropped with groundnut. N-P_2O_5-K_2O at a rate of 20-46-100 kg ha^{-1}; CaO depending on the exchangeable-Al content of the soil.

Improved systems with moderate inputs

Treatment C (**C**)	Cassava intercropped with groundnut. External inputs N-P_2O_5-K_2O at a rate of 40-92-200 kg ha^{-1}; CaO depending on the exchangeable-Al content of the soil.
Treatment D (**D**)	Maize and groundnut in rotation. External inputs N-P_2O_5-K_2O at a rate of 48-73-63 kg ha^{-1}; CaO depending on the exchangeable-Al content of the soil.
Treatment E (**E**)	Yam and groundnut intercropping. External inputs N-P_2O_5-K_2O at a rate of 40-92-200 kg ha^{-1}; CaO depending on the exchangeable-Al content of the soil.

Improved systems with high inputs

Treatment F (**F**)	Maize and groundnut in rotation. External inputs N-P_2O_5-K_2O at a rate of 96-146-126 kg ha^{-1}; CaO depending on the exchange-able-Al content of the soil.

The experiment is set up as a randomized complete block design (RCBD). Each treatment is replicated four times.

Results

Rainfall

The total annual rainfall was above average (Table 1). The monthly rainfall distribution pattern was normal.

Table 1. Total annual rainfall and monthly rainfall distribution at the site (mm).

Month	Average	1992	1993	1994
January	24	0.0	0.0	87.2
February	49	45.8	0.0	127.4
March	140	115.0	0.0	70.7
April	140	190.7	102.0	257.4
May	230	209.0	127.0	180.8
June	330	181.8	254.0	292.4
July	105	28.3	73.0	64.0
August	48	Trace	27.0	59.0
September	112	181.9	119.0	213.5
October	165	258.3	178.0	335.2
November	150	259.9	236.0	101.9
December	49	43.9	30.0	0.0
Annual total	1542	1514.6	1146.0	1789.5

Crop yields

For the validation phase, only one cropping season (1994/1995) has so far been completed (Table 2). Within the cropping systems tested, generally no significant differences in grain yields were obtained between the high-input and the low-input treatments. However, with the exception of yam in treatment A, there was an overall tendency of the high-input treatments to produce slightly higher yields than the low-input treatments.

Table 2. Grain yields in 1994.

System	Crop	Treatment	Yield ($t\ ha^{-1}$)	National average yield ($t\ ha^{-1}$)
Sequence of maize-groundnut	Maize	D	4.76 a	0.90
		F	5.76 a	
	Groundnut	D	1.15 b	0.93
		F	1.20 b	
Association of yam-groundnut	Yam	A	16.58 c	4.90
		E	12.97 c	
	Groundnut	A	0.84 d	0.93
		E	0.91 d	
Association of cassava-groundnut	Cassava	B	24.58 e	5.30
		C	33.04 e	
	Groundnut	B	0.37 f	0.93
		C	0.58 f	

For the same crop and the same system, identical letters indicate nonsignificant differences at the 5% level of probability (Student's t-test).

Differences in the performance of the cropping systems are shown clearly with groundnut. The rotation with maize clearly produced the highest yields, whereas the association with cassava gave the lowest result. However, the effect of the cropping system on crop performance needs to be studied over a longer period.

With the exception of groundnut (in association with cassava), the general level of the yields, compared to the national average in Côte d'Ivoire, is excellent.

Soil characteristics

After only one year of the 'validation phase', there are no striking differences between the treatments (Table 3). However, differences can be clearly observed with available phosphorus and exchangeable aluminium. The lowest available-P level was observed with Treatment B (low input) and the highest with Treatment F (high input). The same observation can be made with exchangeable aluminium. This is in line with the trend in pH. More cropping seasons will be required to confirm trends for the 'validation phase'.

Table 3. Selected soil characteristics (cropping season 1994/1995).

Treatment†	pH (H_2O)	pH (KCl)	Total C (%)	Total N (%)	Avail. P‡ (ppm)	Exch. Al (cmol kg^{-1})	CEC (cmol kg^{-1})
A	5.2	4.2	1.29	0.11	15	0.32	7.33
B	5.1	4.1	1.21	0.12	7	0.26	6.69
C	5.2	4.2	1.08	0.11	12	0.25	6.11
D	4.9	4.1	1.12	0.11	11	0.39	6.41
E	5.2	4.2	1.15	0.11	14	0.32	6.75
F	4.9	4.0	1.07	0.11	20	0.50	6.69

† Treatment A (**A**) Yam intercropped with groundnut; Treatment B (**B**) Cassava intercropped with groundnut; Treatment C (**C**) Cassava intercropped with groundnut; Treatment D (**D**) Maize and groundnut in rotation; Treatment E (**E**) Yam and groundnut intercropping; Treatment F (**F**) Maize and groundnut in rotation.

‡ Olsen-Dabin method.

Land clearing and postclearing soil management in central-south Côte d'Ivoire

G.Yoro*

This is the fourth year of an experiment which started in 1991. The experiment consists of six treatments with three replicates. The rainfall received was above average (1789 mm). Maize yield levels ranged between 2.61 t ha^{-1} on untilled semimechanized plots, and 4.82 t ha^{-1} on tilled and traditionally cleared plots. Generally, tilled plots produced higher maize yields than untilled plots. All maize yields were well above the national average of 0.90 t ha^{-1}. Groundnut yields ranged between 0.67 t ha^{-1} on tilled and traditionally cleared plots and 0.81 t ha^{-1} on tilled semimechanized plots. There was no clear trend between tilled and untilled plots. All groundnut yields were below the national average of 0.90 t ha^{-1}.

Site characteristics

The site is located in a secondary forest area in the south of Côte d'Ivoire, approximately 90 km west of Abidjan. The climate of the region is characterized by a bimodal distribution of rainfall, resulting in two dry seasons, i.e. December to March (long dry season) and August (short dry season). Average annual rainfall is around 1600 mm. The terrain is gently rolling to flat, with maximum slopes of 20%. The soils are moderately acid shallow silty clays and silty sands, classified as gravelly Hyperisothermic Paleustults. The general fertility level is low.

Two traditional cropping systems are practiced in the area: (i) plantain in association with yam and a legume and (ii) an association of cassava and maize. Cash crops grown in the area are coffee, cocoa, oil palm, and coconut. There is a tendency for areas with cash crops to expand, and for areas cropped with food crops to decline.

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Experimental design

The experiments were carried out to observe the long-term effects of initial forest clearing and postclearing soil tillage on the sustainability of continuous cropping.

Land-clearing techniques

T Traditional clearing. Manual cutting of trees and undergrowth. Drying and burning of the cut material at the site. Removal by hand of all unburnt material.

SM Semimechanized clearing. Undergrowth cut manually. Trees are felled using a bulldozer equipped with a ripper. Cut material is pushed to the side.

M Mechanized clearing. Felling of trees and uprooting of undergrowth performed by bulldozer. All material is pushed to the side.

Postclearing soil tillage and management

1 Zero-tillage: no tillage is practiced. Crops are planted by hand into 'pockets'. Contact herbicide is applied at the time of planting; manual weeding; crop residues are left on the plot; fertlizer application of NPK (250 kg ha^{-1}); and tri-calcium phosphate (750 kg ha^{-1}).

2 Minimum tillage: soil tillage is only carried out superficially with a handhoe; manual weeding. Crop residues are left on the plot; fertlizer application of NPK (250 kg ha^{-1}); and tri-calcium phosphate (750 kg ha^{-1}).

The resultant treatments were as follows:

T1 Traditional clearing; zero-tillage.
T2 Traditional clearing; minimum tillage.
SM1 Semimechanized clearing; zero-tillage.
SM2 Semimechanized clearing; minimum tillage.
M1 Mechanized clearing; zero-tillage.
M2 Mechanized clearing; minimum tillage.

Each plot has a size of 200 m^2; each treatment is replicated three times; all plots are cropped with maize and groundnut in rotation.

Results

Rainfall

The total annual rainfall was above average (Table 1). The monthly rainfall distribution pattern was normal.

Table 1. Total annual rainfall and monthly rainfall distribution at the site (mm).

Month	Average	1992	1993	1994
January	24	0.0	0.0	87.2
February	49	45.8	0.0	127.4
March	140	115.0	0.0	70.7
April	140	190.7	102.0	257.4
May	230	209.0	127.0	180.8
June	330	181.8	254.0	292.4
July	105	28.3	73.0	64.0
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October	165	258.3	178.0	335.2
November	150	259.9	236.0	101.9
December	49	43.9	30.0	0.0
Annual total	1542	1514.6	1146.0	1789.5

Crop yields

For maize, the yields were generally higher than in 1993. The treatments with tillage had significantly better yields than the treatments without tillage (Table 2). Overall, the best performance was achieved with traditional clearing, and the lowest performance with mechanical clearing. The yields obtained were significantly higher than the overall national average for maize (i.e. 0.90 t ha^{-1}).

For groundnut, the yields are declining as compared with the previous years. As distinct from maize yields, no general response of the yield to tillage could be observed (Table 2). The best result was obtained in semimechanized clearing with tillage. The lowest yield was produced by the mechanized plot with tillage. The overall yield level of the experiment was lower than the national average yield for groundnut (i.e. 0.93 t ha^{-1}).

Table 2. Average crop yields (1994 harvest).

Crop	Treatments					
	T1	T2	SM1	SM2	M1	M2
Maize (t ha^{-1})	3.22	4.82	2.61	4.19	2.83	3.82
Groundnut (t ha^{-1})	0.76	0.67	0.71	0.81	0.71	0.43

Soil characteristics

For this year, no marked differences could be observed between the treatments (Table 3). With regard to carbon, nitrogen, and the cation-exchange capacity, the untilled treatments showed higher levels than the untilled treatments. The opposite was true for the levels of available phosphorus, which were higher in the tilled plots than in the untilled plots. No other clear trends can be observed with this year's results.

Table 3. Selected soil characteristics (after 1994 harvest).

	Treatments					
	T1	T2	SM1	SM2	M1	M2
pH	4.7	4.7	4.9	4.6	4.6	4.6
Total c (%)	1.48	1.28	1.59	1.23	1.37	1.18
Total N (%)	0.14	0.12	0.16	0.11	0.13	0.12
Avail. P (ppm)†	41	46	32	41	38	53
Exch. Al (cmol kg^{-1})	0.71	0.75	0.72	0.94	1.12	1.14
CEC (cmol kg^{-1})	8.99	8.86	10.43	8.91	8.91	8.21

† Olsen-Dabin method.

Management of Nigerian acid soils for optimum productivity

A. Olu Obi*

The experiment has covered a period of three cropping cycles. In the first year, maize and cassava were destroyed completely by termite attack. With the exception of cassava, crop yields are generally declining over time, irrespective of treatment. Over a period of one year, maize yields declined by 15 to 50%. For the same period, cowpea yields even declined to between 55 and 85%. This was probably due to a rapid loss in soil fertility caused by chemical degradation of the soil, but soil analyses still have to be evaluated. Cassava yields in the traditional system were lowest (13.58 t ha^{-1}). As expected, the highest yields were obtained with high fertilizer inputs (31.48 t ha^{-1}). Except for cassava, a positive effect of fertilizer application in the low-input system was not observed. In this paper, only the core experiments are reported.

Site characteristics

The experimental site is located in the high-rainfall area of southwestern Nigeria, near the town of Ogere in Ogun State. The climate is humid with pronounced dry (November-March) and wet (April-October) seasons. The rainy season has two peaks, i.e. June/July and September/October. The mean annual rainfall is around 1345 mm. Mean air temperatures range between 27° and 32°C. The dominant vegetation is secondary forest. The soils are usually deep, well-drained, brown to reddish-brown ferralitic soils. The majority of the land-users are smallholders. The traditional system of food-crop farming is slash-and-burn shifting cultivation, with cassava as the main staple crop. The main cash crop is kolanut.

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Experimental design

The experiments were set up to test the sustainability of cropping systems which can be adopted by small-scale farmers with limited access to external inputs.

The experiments are arranged in a randomized complete block design (RCBD). Each treatment is replicated four times. The plot size is $100m^2$. The test-crops grown are maize and cassava intercropped during the early season and cassava and cowpea intercropped during the late season. For all treatments, seedbed preparation is carried out manually. All crop residues, except for cassava, are returned to the soil. All treatments start with slash-and-burn clearing of the original fallow vegetation.

Treatment 1: Traditional system (**T1**). A maize-cassava intercrop was planted in a mixed pattern as practiced by the farmers of the region in the first cropping season. In the late season, cowpea was intercropped with cassava after the maize had been harvested. Weeding was carried out manually.

Treatment 2 Improved fallow (**T2**). After the first year of maize-cassava/cassava-cowpea intercrop, pueraria was planted to cover the ground. The ground cover was allowed to grow for one year, after which it was cut and incorporated into the soil. No fertilizer, ime, or agrochemicals were applied.

Treatment 3: Low-input system (**T3**). The same crops were used as in **T1**. A minimum fertilizer input was applied once in three years, which consisted of N-P-K at rates of 30:20:20 kg ha^{-1}.

Treatment 4 High-input system (**T4**). A maize-cassava/cassava-cowpea intercrop was used as in **T3**, and with a high level of external input. N-P-K at rates of 120:80:100 kg ha^{-1} was applied, and lime at a rate of 500 kg ha^{-1}. Weeds were eliminated with a herbicide.

Results

The studies reported here are not complete because of their long-term nature. However, some interesting and useful observations can already be made. The initial fertility status of the soil was typical for the area and was considered adequate for the crops to be grown.

Crop yields

After the second cropping cycle, the results show that yields are declining, irrespective of the treatment (Table 1). A response to lime addition is not expected before the plot has been cropped continuously for three years. Soil chemical analyses have yet to be interpreted to correlate the degree of decline of yields to the deterioration of soil properties.

Table 1. Crop yields (t ha^{-1}).

	Maize		Cowpea		Cassava	
	1993	1994	1992	1993	1993	1994
T1 Traditional	1.01	0.53	0.11	0.04	13.58	24.94
T2 Impr. fallow	1.38	-	0.27	0.04	15.75	-
T3 Low input	1.38	1.18	0.28	0.04	19.10	39.88
T4 High input	2.09	1.31	0.22	0.10	31.48	45.56

Maize

In the early season of 1992, the maize crop was attacked by termites. Despite spraying, all the maize plants were destroyed. In 1993, grain yields ranged from 1.01 t ha^{-1} in the traditional system to 2.09 t ha^{-1} in the high-input system (Table 1). There were no differences between the improved fallow and the low-input treatment, indicating a ack of response to the level of fertilizer applied under the low-input system. The lowest yield (from the traditional treatment) could be attributed partly to the low plant population. Also, three to four seeds were planted per planting hole, and consequently several plants competed for both nutrient and moisture within the same root zone area. Grain yields fell sharply in the following year (1994), indicating a decline in soil fertility. Even in the high-input treatment, the grain yield dropped to around 60% of the initial level.

Cowpea

The cowpea yield followed a similar pattern to that of the maize. There were no very notable differences between the treatments, which demonstrates the lack of response to fertilizer. Compared with typical yields for southwestern Nigeria, the yields obtained in the experiments were very low. The plant growth was adversely affected by the shade produced by the cassava, and this effect increased in 1993 when an improved IITA cassava variety was planted which provided much more shade than the local variety planted in 1992. In 1993 the grain yield was extremely low, falling to 45% (high input), 36% (traditional) and 14% (improved fallow and low input) as compared to 1992. This trend is a clear indication of the decline in soil fertility.

Cassava

The local variety was planted in 1992 and harvested in the early season of 1993. There was not much difference in the tuber yield between the traditional improved fallow and low-input systems. A slight response (but not significant) to fertilizer application under the low-input system was observed. In the high-input system, a highly significant response to added fertilizer was obtained. The yield in the second year (1994) was higher than in the first year (1993).

Conclusions and recommendations

The results so far indicate that the soil has a strong tendency to chemical degradation. The quantity of residue produced by cowpea was very low, and decreased even further with the decline in the fertility status of the soil. Hence, a legume which produces sufficient biomass should provide adequate soil cover and residue to improve both the physical and chemical properties of the soil. The addition of lime may not be economically wise until the plot has been cropped continuously for three years, and soil tests should precede the application.

From the results available so far, it is presumed that the combination of an improved fallow system with low external input could support the crops being grown better than the presently tested systems. The proposed system should include a legume that will produce sufficient vegetative cover and biomass to improve the organic-matter status of the soil.

Land clearing and post-clearing soil management for sustainable crop production in Nigeria

A. A. Agboola*

The first harvest of maize and cowpea was secured. Climatic conditions were average, but soil tillage could not be carried out as planned due to the numerous stumps remaing in the plots after clearing. All other cropping practices were carried out according to schedule. The highest yields were obtained from the manually cleared plots (maize 4.1 t ha^{-1}; cowpea 1.3 t ha^{-1}). The lowest yields were recorded on the mechanically cleared and windrowed plots (maize 2.6 t ha^{-1}; cowpea 0.9 t ha^{-1}). However, the results are not yet conclusive and further cropping seasons are required to determine definite trends.

Site characteristics

The experimental site is located in a forest reserve of the Ondo State Afforestation Project at Epemakinde, southwest Nigeria, approximately 180 km southeast of Ibadan. The vegetation of the area is secondary high forest. In average annual rainfall is around 1800 mm, with rain falling for eight or more months during the year. The altitude is around 150 m asl, and the topography is gently sloping with gradients below 5%. The dominant soil types are well-structured Nitosols and Acrisols with medium textures; pH-levels range from 4.9 to 6.7. Cation-exchange capacities are low, and the general fertility status of the soils are rated as low to moderate.

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Experimental design

The experiments were designed to develop improved and sustainable land-clearing methods and postclearing techniques for the humid forest areas of southern Nigeria. A randomized complete-block experiment with three replicates was set up at the site, and a maize and cowpea cropping system (typical for the area) was used in the experiment.

Slash-and-burn (**T1**). After manual clearing, some scattered trees were left. Small trees were cut and burnt, and the stumps and unburnt logs were left on the ground.

Mechanical clearing (**T2**). A bulldozer was used to knock down the trees. The logs and scrub were windrowed and burnt after drying.

Semi-mechanized clearing (**T3**). A bulldozer was used to knock down the trees. There was no windrowing, and the logs were carried away manually. The debris was burnt *in situ*, and unburnt logs were left in place.

Mechanical clearing without planting a crop (**T4**). This was the reference plot for **T2**.

Slash-and-burn without planting a crop (**T5**). This was the reference plot for **T1**.

Results

Tillage could not be practiced as planned because a great many stumps remained on the plots. Loosening of the soil was therefore only done at the planting holes.

General observations

Land clearing compacts the soil, and the compaction is increased by windrowing. The slash-and-burn practice is slow, and a lot of organic material is left behind. In the present study, over 30 t of organic material per hectare was left on the plots after clearing. Therefore, no planting could be done without first burning the residue. The stumps remaining in the plots reduced the cultivable area by around 5%. On the mechanically cleared plots, erosion could already be observed during during the first year.

Crop development and crop yields

Maize. The manually cleared plots showed better growth than the bulldozed plots (Table 1). Differences in plant height, ear number per plant, and stem girth were not significant. Highly significant differences were observed for leaf area. Bulldozed and windrowed plots (**T2**) were not significantly different from bulldozed, unwindrowed plots (**T3**). Cob number, stover and grain yields were significantly higher from slash-and-burn (manually cleared) plots (**T1**) than from bulldozed and windrowed plots and from unwindrowed plots (**T2** and **T3**).

Cowpea. Among the parameters recorded for cowpea, only the leaf number, leaf area and number of branches showed significant variation. The manually cleared plots (**T1**) were about 25% better respectively than the bulldozed plots (**T2** and **T3**). Grain yield was 27% higher in the manually cleared plots (**T1**) than in the bulldozed plots (**T2** and **T3**) (Table 1).

Table 1. Crop yields.

	T1		T2		T3	
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
Grain yield (t ha^{-1})	4.1	1.3	2.6	0.9	3.8	1.0

Soil characteristics

An overview of the results obtained so far is given in Table 2. Soil chemical analyses were carried for depths from 0-15 cm and 15-30 cm. Samples were collected before the start of the experiment and at the end of the first year.

Bulk density. A significant difference existed between the natural forest and bulldozed plots, but such differences do not exist between bulldozed and windrowed plots and bulldozed, unwindrowed plots. Slight differences were observed between slash-and-burn (**T1**) and bulldozed plots (**T2** and **T3**).

Soil pH. There was a slight overall increase in soil pH values at the 0-15 cm depth. It was less in slash-and-burn plots than in bulldozed plots. The trend at the 15-30 cm depth was inconsistent.

Table 2. Selected soil characteristics.

	T1		T2		T3		T4		T5		Before experiment	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
BD	1.4	1.5	1.4	1.6	1.4	1.7	1.3	1.5	1.3	1.7	1.1	1.4
$pH(H_2O)$	6.4	6.2	6.3	6.2	6.6	6.6	6.2	6.2	6.2	6.2	6.2	6.3
Tot. N	0.20	0.12	0.17	0.13	0.22	0.17	0.23	0.15	0.23	0.15	0.26	0.16
Avail. P	4.7	1.8	6.1	2.1	6.8	3.1	4.3	2.4	5.1	1.9	6.2	2.2
ECEC	3.4	2.3	3.1	2.7	4.5	3.8	3.3	1.9	3.5	2.1	4.4	2.3
OM 1	5.3	3.0	5.3	3.0	5.3	3.0	5.3	3.0	5.3	3.0	5.3	3.0
OM 2	3.9	2.3	3.1	2.2	3.9	2.6	3.9	2.2	4.5	2.9	-	-

BD - bulk density ($g\ cm^{-3}$); Tot. N. - total N (%); Avail. P - available P ($mg\ kg^{-1}$); ECEC - effective cation-exchange capacity ($cmol\ kg^{-1}$); OM 1 - organic matter (%) after clearing; OM 2 - organic matter (%) after 1 year.

Total nitrogen. Total N values decreased with depth in all the treatments except in the bulldozed unwindrowed plots (T3) where there was even a slight increase. The reduction was higher in the bulldozed plots (T2 and T3) than in the slash-and-burn plots. The reduction in the uncropped plots (T4 and T5) was much less than in the cropped plots.

Available P. Available P declined in all plots except in the bulldozed plots which had not been windrowed (T3). In the slash-and-burn plots (T1), the decline was limited to 15-30 cm depth.

Effective cation-exchange capacity (ECEC). With the exception of the bulldozed unwindrowed plots (T2) and the bulldozed and windrowed plots (T1), there was a general decrease in ECEC irrespective of the treatment. In the 0-15 cm layer, the reduction ranged from 21% in the unplanted slash-and-burn plots to 30% in the bulldozed plots. In the 15-30 cm layer, the change ranged from 2% in slash-and-burn to 18% in the unplanted bulldozed plots.

Base saturation. There were overall slight decreases in base saturation, irrespective of treatments and soil depth.

Organic matter. There was a general decline in organic matter with depth in all treatments. The values ranged from 0.01% in the bulldozed + windrowed plots (T2) to 4.5% in the unplanted slash-and-burn plots (T5).

Preliminary conclusions

The results show that perhaps the best way of opening up new land for cultivation would be to knock down the big trees by bulldozer without subsequent windrowing, to salvage the logs (cross-cutting the smaller trees by chainsaw), and to burn the remaining organic matter after drying. The nutrient status of the virgin soil is low. The base saturation of the topsoil is about 90%. With an ECEC of about 5 cmol kg^{-1}, available P of less than 10 mg kg^{-1} and the rapid decline of organic matter, careful management of the soil is crucial.

Management and improvement of acid soils for sustainable agriculture in central Cameroon

J. Kotto-Same and M. Tchienkoua*

During the reporting period, all activities were carried out as per work plan. On treatments T3 and T4, maize, groundnut, and cassava were grown. Treatment T1 was under natural fallow, treatment T2 was planted with Pueraria phaseoloides. Exept for cassava, no pest attacks which had an effect on the yield were observed. As expected, the best results were obtained from T4, which had a high level of external inputs (maize 5.45 t ha^{-1}; groundnut 0.75 t ha^{-1}). However, the overall level of yields was low. For the intercropping practices (T3) this is thought to be due to the competition between the crops. Given the short duration of the experiment, final conclusions cannot yet be drawn.

Site characteristics

The experimental site is located at the IRA research farm at Minkoameyos, in the forest zone of Central Cameroon, approximately 15 km south of Yaoundé. The mean altitide is 740 m asl. The topography of the area is generally undulating, and the average slope of the site is 15%. The average annual rainfall is approximately 1500 mm. The rainfall pattern is bimodal with peaks in May and September.

The typical vegetation in the area is characterized by secondary forest and old-fallow vegetation, with thick understorey cover. Primary forest no longer exists.

The soils in the area are relatively homogenous Rhodic Kandiudults. The texture is loamy in the topsoil and clayey in the lower horizons. The soils are slightly acid to acid with pH (H_2O)-values between 4.1 and 5.7. Soil organic-matter levels are moderate, N and P levels are low to moderate. The soil fertility is generally rated as low to moderate.

The majority of farmers in the area are smallholders. The major crops grown are cassava (*Manihot esculenta*), groundnut (*Arachis hypogaea*), plantain (*Musa balbisiana*), cocoyam (*Xanthosema sagittifolium*), maize (*Zea mays*), and cocoa

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(*Theobroa cacao*). Intercropping is the most widely pacticed cropping system. After clearing, the land is usually cultivated for a period of three years. It is then returned to several years' of bush fallow.

Experimental design

The experiments consist of four treatments based on a cropping system with maize, groundnut, and cassava. Each treatment is replicated 4 times.

Treatment 1 (T1)

This is the traditional system whereby forest clearing is done by hand. Wood is removed from the plot, branches and leaves are burnt on the site, and soil tillage (using a handhoe) is minimal. Maize, groundnut, and cassava are intercropped. Maize and groundnut are planted at the same time, and cassava is planted three weeks later. Maize and groundnut are harvested in July to make space for the cassava. Cassava is harvested after 12 months. The plot is then left as fallow for three years.

Treatment 2 (T2)

This is an improved-fallow treatment, similar to **T1**. In the second year, each plot is planted with a legume cover crop, *Pueraria phaseoloides*. In the third year, the cover crop is weeded manually and incorporated in the soil during the tillage operation.

Treatment 3 (T3)

This is a treatment using low external inputs, with cultural practices similar to those adopted for **T1** and **T2**, i.e. the same crops and the same management practices. The plots are fertilized with NPK at a rate of 20-10-10 kg ha^{-1}, and with urea at a rate of 46 kg ha^{-1}. The first NPK application is given ten days after planting at a rate of 2.5 kg per plot. Urea is given 30 days after planting at a rate of 4.5 kg per plot.

Treatment 4 (T4)

This system has high external inputs, and should normally employ fully mechanized soil tillage at the preliminary stage. However, due to dificulties in securing a tractor for the tillage operations. manual tillage to a depth of 15 cm was adoppted. Maize (major season) and groundnut (minor season) are planted in rotation. Fertilizer applications are identical to T3. Lime is applied to neutralize the exchangeable aluminium up to a soil depth of 20 cm. The application rates are calculated according to the Kamprath method, using an average of the soil characteristics of the experimental site, and assuming an average soil density of 1.2 g cm^{-3} and an exchangeable aluminium content of 0.84 cmol kg^{-1}. Gramoxone is used as a herbicide three days after planting.

Results

Rainfall

The overall annual rainfall was normal (Table 1). The rainfall pattern was typical for the area. With the exception of October, all months received typical total amounts of rain. In October, unusually heavy downpours occurred, but did not affect farming operatons and plant growth significantly.

Table 1. Total annual rainfall and monthly rainfall distribution at the site (mm).

Month	11-year average	1993	1994
January	13.7	0.0	36.5
February	56.6	41.9	43.9
March	147.6	127.3	181.3
April	187.7	172.7	196.1
May	220.7	117.1	165.4
June	173.1	144.2	154.7
July	66.0	33.3	5.1
August	82.3	125.1	81.9
September	245.0	297.1	146.3
October	302.3	187.8	403.1

Table 1. cont'd.

Month	11-year average	1993	1994
November	106.7	155.6	88.1
December	15.8	1.9	0.0
Annual total	1617.5	1404.0	1502.4

Crop yields

Treatment 1 (T1), the traditional system, was under fallow in 1994. During the same period, Treatment 2 (T2) , the improved fallow system, was under *Pueraria phaseoloides*. Table 2 gives the 1994 results, and compares them with those of 1993. Germination rates in both years were good. The planting material was of high quality and the cultural practices were carried out correctly, and there were no attacks from pests.

Table 2. Crop yields and germination rates per treatment.

	Maize				Groundnut				Cas-sava
	T3		T4		T3		T4		T3
Year	Germ. (%)	Yield (t ha^{-1})	Germ. (%)	Yield (t ha^{-1})	Germ. (%)	Yield (t ha^{-1})	Germ. (%)	Yield (t ha^{-1})	Yield (t ha^{-1})
1993	99	3.06	93	4.98	97	1.04	99	1.29	14.00
1994	91	3.12	83	5.45	-	-	98	0.75	11.00

In both years, the high external inputs treatment (T4) produced the best overall yields for maize, and for both treatments, a slight increase in yields was observed. For groundnut and for cassava, there was a slightly decreasing trend in yields. For the decrease in cassava yield, the attack by cassava beetles (locally called 'kop'), was responsible. Also, competition between the crops in T3 may have had a negative impact on the yield, but it is too early yet to draw conclusions from the experiment - indicating that further cropping seasons are required.

Land clearing and post-clearing management of acid soils in forested areas of central Cameroon

R. Ambassa-Kiki and V. Agoumé*

No major problems were encountered in the execution of this project, and all project activities were carried out in accordance with the schedule. During the reporting period, two crops (i.e. cowpea and maize) were grown and harvested on the traditional and semimechanized plots. The cropping seasons received normal rainfall. No special pest attacks or plant deseases occurred. However, germination, especially for cowpea, was low (i.e. between 56 and 78 %). There seemed to be no particular cause for the below-average yields. For maize, the zero-tillage treatments (i.e. traditional and semimecha-nized) had the highest yields. However, the differences were not statistically significant. For cowpea, the traditional treatment with zero-tillage performed best, although the germination rate was the lowest.

Site characteristics

The experimental site is located at the IRA research farm at Minkoameyos, in the forest zone of central Cameroon, approximately 15 km south of Yaoundé. The mean altitide is 740 m asl. and the topography of the rea is generally undulating. The average slope of the site is 15%, and the average annual rainfall is approximately 1500 mm. The rainfall pattern is bimodal with peaks in May and September.

The typical vegetation in the area is characterized by secondary forest and old-fallow vegetation with thick understorey cover. Primary forest no longer exist.

The soils in the area are relatively homogenous Rhodic Kandiudults - loamy in the topsoil and clayey in the lower horizons. The soils are slightly acid to acid with pH (H_2O)-values between 4.1 and 5.7. Soil organic-matter levels are moderate, and N and P levels are low to moderate. The soil fertility is generally rated as low to moderate.

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The majority of farmers in the area are smallholders. The major crops are cassava (*Manihot esculenta*), groundnut (*Arachis hypogaea*), plantain (*Musa balbisiana*), cocoyam (*Xanthosema sagittifolium*), maize (*Zea mays*), and cocoa (*Theobroa cacao*). Intercropping is the most widely pacticed cropping system. After clearing, the land is usually cultivated for a period of three years. It is then returned to several years' of bush fallow.

Experimental design

The experiments were designed to observe the long-term effects of three different initial land-clearing techniques in combination with different subsequent soil tillage methods under continuous cropping.

Land-clearing techniques

M *Mechanized clearing*. Clearing with a 200 HP tracklayer tractor; regular windrowing; no burning.

S *Semimechanized clearing*. Clearing of undergrowth with machete; tree felling with a chainsaw, manual removal of the wood; no burning.

T *Traditional clearing*. Clearing of undergrowth with machete; tree felling with a chainsaw, burning of the brushwood on the site.

Soil tillage methods

z *Zero tillage*. The soil is not tilled; a machete or garden hoe is used for planting.

t *Traditional tillage*. A handhoe is used for tillage.

c *Conventional tillage*. Tillage with a tractor-drawn disk plough.

The following combinations of clearing and soil tillage methods were tested:

Mechanized clearing (**M**). Randomized complete-block design (RCBD):

Mz Mechanized clearing + zero-tillage

Mt Mechanized clearing + traditional tillage

Mc Mechanized clearing + conventional tillage

Semimechanized (**S**) and *traditional* (**T**) clearing. Randomized complete-block design (RCBD):

Sz Semimeachanized clearing + zero tillage

St Semimeachanized clearing + traditional tillage
Tz Traditional clearing + zero tillage
Tt Traditional clearing + traditional tillage

Each treatment is replicated three times. The plot size is 600 m^2 (40 m x 15 m). Because of the stumps and roots remaining in the semi-mechanized (S) and the traditional cleared (T) plots, these cannot be tilled with a conventional disk plough, and consequently conventional tillage is only practiced in plots where mechanized clearing was used.

The crops grown are maize in the major season, in rotation with cowpea (*Vigna unguiculata*) in the minor season. In the mechnized plots (M), a pueraria fallow (*Pueraria phaseoloides*) was grown for two years before cropping started.

Results

Rainfall

The overall annual rainfall was normal (Table 1), and the rainfall pattern was typical for the area. Except for October, all months received typical total amounts of rainfall. In October, unusually heavy downpours occurred, but this did not affect farming operations and plant growth significantly.

Table 1. Total annual rainfall and monthly rainfall distribution at the site (mm).

Month	11-year average	1993	1994
January	13.7	0.0	36.5
February	56.6	41.9	43.9
March	147.6	127.3	181.3
April	187.7	172.7	196.1
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Table 1. cont'd.

Month	11-year average	1993	1994
September	245.0	297.1	146.3
October	302.3	187.8	403.1
November	106.7	155.6	88.1
December	15.8	1.9	0.0
Annual total	1617.5	1404.0	1502.4

Crop yields

As planned in the experimental design, the plots subjected to mechanized clearing were still under pueraria fallow. Generally, this year's maize yields were not significantly diferent from last year's yields. However, cowpea yields dropped sharply. Although the results have not yet been analyzed statistically, it is clear that with both crops, the zero-tillage treatments performed best (Table 2). The traditional + zero-tillage treatment gave the highest yields, although, as in the case of cowpea, rates of germination were extremely low. The reason for this has not yet been established.

Table 2. Mean crop yields and degree of germination (1994).

Treatment	Maize		Cowpea	
	Germination (%)	Grain Yield (kg ha^{-1})	Germination (%)	Grain Yield (kg ha^{-1})
Mz	*	*	*	*
Mt	*	*	*	*
Mc	*	*	*	*
Sz	91	6200	56	443
St	79	5730	67	406
Tz	90	6070	56	531
Tt	87	5950	78	425

* All plots using mechanized clearing (M) were grown to pueraria fallow.

Soil characteristics

Preliminary examination of the soil data show no extreme trends (Table 3). pH values, organic-matter content, available phosphorus, and nitrogen contents were generally higher in the topsoil. A general decrease of nutrients over time was not observed during the year under review.

Table 3. Selected soil analytical data per treatment (1994).

	Depth	After cowpea				After maize			
	(cm)	Sz	St	Tz	Tt	Sz	St	Tz	Tt
pH	0-10	5.4	5.5	6.4	6.4	5.7	5.6	7.0	5.8
(H_2O)	10-30	4.8	5.2	5.2	4.7	5.0	5.0	6.1	4.9
OC	0-10	1.34	1.56	1.16	1.53	2.12	1.72	1.93	1.79
(%)	10-30	0.49	0.92	0.43	0.39	1.00	0.88	0.92	0.85
Av.P.	0-10	5.0	5.0	10.3	9.6	5.8	2.7	6.7	5.2
(ppm)	10-30	2.3	2.7	3.3	3.0	2.3	1.7	3.3	1.7
Al	0-10	0.07	0.10	0.01	0.03	0.26	0.11	0.04	0.11
(cmol kg^{-1})	10-30	0.34	0.08	0.18	0.08	0.62	0.40	0.40	0.47
Tot. N	0-10	0.26	0.17	0.15	0.18	0.24	0.21	0.23	0.22
(%)	10-30	0.12	0.13	0.11	0.11	0.14	0.15	0.14	0.14
CEC	0-10	-	-	-	-	10.46	9.01	9.62	9.57
(cmol kg^{-1})	10-30	-	-	-	-	8.21	8.28	7.98	8.14
BS (%)	0-10	-	-	-	-	64	61	92	62
	10-30	-	-	-	-	31	37	68	38

The management of acid soils for cassava based cropping systems in the Niari Valley, Congo

B.Nyete*

The project has had three years of experimentation, equivalent to one cropping cycle. Six cropping systems with different levels of external inputs are being investigated. During the reporting period, cassava, maize and groundnut yields were measured. In the case of cassava, high-input levels gave the highest yields. However, this trend could not be observed with groundnut. With maize, there were no differences between the two high-input systems tested.

Site characteristics

The site is located at the Loudima Research Station of CRAL (Centre de Recherche Agronomique) in southern Congo, approximately 250 km west of Brazzaville. The terrain is flat to slightly undulating. The natural vegetation is savanna. The average annual rainfall is about 1050 mm, with a monomodal distribution and a long dry season. There are two rainfall peaks - in November/December and in April, and about 80 rainy days in a year. The dominant soils are acid yellow ferralitic clays and clay loams. The contents of exchangeable aluminium are high, and hardpans are developed under prolonged cultivation. The traditional cropping system in the area is based on two years of cropping with cassava and groundnut followed by four years of fallow. External inputs are not used.

Experimental design

The experiments are designed to test the effects of different levels of external inputs

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and soil management practices on the sustainability of crop yields and the acidity level of the soils. The treatments are based on cropping systems common in the area.

Treatment NF	*Natural fallow*. Permanent natural fallow as control treatment.
Treatment T	*Traditional system*. System based on cassava. Manual cultivation of cassava (2500 plants ha^{-1}) on irregular mounds for two years with an intercrop of groundnut in the first year, and then two years of fallow.
Treatment I1	*Improved traditional system-1*. This system is based on cassava. Manual cultivation of cassava (8333 plants ha^{-1}) on flat ground and in rows, with an intercrop of groundnut in the first year. Followed by two years of mucuna fallow. Liming at a rate of 3 t ha^{-1} in the first year.
Treatment I2	*Improved traditional system-2*. This system is based on cassava. Two years of mucuna fallow are followed by two years of cassava (8333 plants ha^{-1}), planted on flat ground and in rows and intercropped with groundnut in the first year.
Treatment H1	*High-input system-1*. This system is based on cassava. One crop of cassava (10,000 plants ha^{-1}) on flat ground and in rows. Mechanized soil tillage. Initial liming at a rate of 3 t ha^{-1} and fertilizer application of NPK 8-5-20 at a rate of 250 kg ha^{-1}.
Treatment H2	*High-input system-2*. This system uses a rotation of groundnut, maize, and cassava, in association with mechanized soil tillage. Initial liming is applied at a rate of 3 t ha^{-1} and NPK (8-5-20) is applied at a rate of 250 kg ha^{-1}.
Treatment H3	*High-input system-3*. This system uses an annual rotation of soybean, maize, and soybean in association with mechanized soil tillage. Initial liming is applied at a rate of 3 t ha^{-1} and NPK (8-5-20) is applied at a rate of 250 kg ha^{-1}.

An overview of the cropping sequence for each treatment is given in Table 1.

Table 1. Cropping sequences for each treatment.

Treatment	Cropping year		
	1992/93	1993/94	1994/95
NF	Fallow	Fallow	Fallow
T	Cassava/groundnut	Cassava	Fallow
I1	Cassava/groundnut	Cassava	Mucuna

Table 1. cont'd.

Treatment	Cropping year		
	1992/93	1993/94	1994/95
I2	Mucuna	Mucuna	Cassava/groundnut
H1	Cassava	Cassava	Groundnut
H2	Groundnut	Maize	Cassava
H3	Soybean	Maize	Soybean

The treatments are arranged as a randomized complete-block design (RCBD), with four replicates. Each experimental plot has an area of 384 m^2 (32 m x 12 m).

Results

Rainfall

Overall, the rainy season was adequate (Table 2). The typical short dry spell in January and February was more pronounced than usual, but this had no effect on the crop.

Table 2. Rainfall distribution at the site (mm).

	Agricultural year			
	1991-92	1992-93	1993-94	10-year average
October	0	20.2	52.6	89.6
November	264.6	170.4	233.5	195.3
December	124.1	211.0	255.8	186.0
January	10.6	185.1	44.4	103.4
February	236.0	116.9	73.3	135.4

Table 2. cont'd.

	Agricultural year			
	1991-92	1992-93	1993-94	10-year average
March	77.7	107.1	155.1	181.8
April	140.6	81.9	285.4	174.1
May	80.6	2.7	141.3	104.2
June	0	23.8	0	4.7
July	0	0	0	0.6
August	0	0	0	0.5
September	17.3	0	6.5	4.1
Total	951.1	919.1	1347.9	1179.7

Crop yields

For the 1993/94 season, cassava and maize were harvested. For the 1994/95 season, only groundnut yields are available (Table 3). As expected, the high-input system **H1** performed best with cassava. The yields of the traditional system **T** and the improved system **I1** with lime were significantly lower. A positive effect of liming alone has not yet been clearly established. With maize, both high-input systems, **H1** and **H2**, performed equally well. No significant differences could be observed between these two treatments. It is noteworthy that in the case of groundnut, the output of the high-input system **H2** was considerable lower than both the traditional (**T**) and the improved system **I2**.

Table 3. Average crop yields (t ha^{-1}).

	Treatment					
	T	I1	I2	H1	H2	H3
1993/1994						
Cassava	21.01	19.58		28.70		
Maize					3.406	3.447
1994/1995						
Groundnut	1,990		2.186		1.888	

Soil characteristics

Because of institutional problems, soil analyses are not yet available.

Land clearing and soil management for sustainable food production in the high-rainfall zone around Lake Victoria, Uganda

J.Y.K. Zake and C. Nkwiine*

The data from third year of experimentation are now available. Climatic conditions throughout the period were normal, and there were no striking differences in either crop yield or soil characteristics. However, there is a clear trend indicating more favourable soil conditions and higher yields with the mechanized and fertilized treatment. A final detailed analysis has yet to be carried out.

Site characteristics

The site is located at the Makerere University Agricultural Research Institute (MUARIK) at Kabanyolo, approximately 12 km north of Kampala at an altitude of about 1,100 m. The terrain is generally undulating to hilly with steep upper slopes and flatter lower slopes. The climate is a typical 'highland climate', with average monthly temperatures of 24.5°C. The mean annual rainfall is 1160 mm, distributed over two rainy seasons - March to June, and September to November. The natural vegetation of the area is dominated by tall elephant grass (*Pennisetum puparem*) with some tropical forest. The main staple crops grown in the area are plantain, maize, beans and sweet potatoes. Coffee is the main cash crop. The annual crops are usually grown in a three-year rotation, followed by a three-year natural grass fallow. Farm holdings are small and continuous cropping without proper soil management has led to serious soil degradation.

Experimental design

The setup of the experiments was based on the effect of different clearing methods

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and postclearing soil management practices on the sustainability of a typical maize-beans rotation under continuous cropping. Four treatments were developed.

T	*Traditional.* Traditional slash-and-burn clearing. Handhoe cultivation. Removal of crop residues.
SMB	*Semimechanized.* Slash-and-burn clearing. Tractor cultivation with a disk plough. Burning of crop residue on the plot.
SMNB	*Semimechanized (no burn).* Slash clearing without burning the bush. Tractor cultivation with a disk plough. Returning the crop residue.
ME	*Mechanized.* Clearing with a bulldozer. Tractor cultivation with a disk plough. Incorporating the crop residue. Application of N-P_2O_5-K at a rate of 80:200:60 kg ha^{-1}.

The experiment was set up as a randomized complete-block design (RCBD). Each treatment was replicated three times on plot of 360 m^2 (9 m x 40 m). The average slope of the plots is 11%.

Results

Rainfall

The annual rainfall was slightly above average (Table 1). No climatic restrictions were observed during the cropping year.

Table 1. Annual and monthly rainfall at the site.

	1992	1993	1994
January	28.4	64.9	20.4
February	22.9	53.6	65.3
March	93.6	146.2	63.9
April	183.6	54.4	105.9
May	231.3	143.6	230.6
June	50.0	131.3	33.0
July	38.7	0.0	167.3

Table 1. cont'd.

	1992	1993	1994
August	83.0	48.3	58.4
September	151.9	163.7	108.5
October	195.9	158.2	152.8
November	74.8	42.1	210.0
December	94.2	36.8	94.9
Total	1248.0	1043.0	1311.0

Crop yields

For maize, the highest yields, as expected, were obtained from the fully mechanized and fertilized plots ME (Table 2). Both the traditional treatment (T) and the semimechanized treatment with residues incorporated (SMNB) produced lower but approximately equal yields. The semimechanized treatment with burning of the residues (SMB) had the lowest yields, although some nutrients should have been made available by the burning of the residues. An explanation for this has not yet been found. For beans, the same trend can be observed although the relative differences between the individual treatments are higher.

Table 2. Crop yields in 1994 (kg ha^{-1}).

	Treatments			
	T	SMB	SMNB	ME
Maize	5036	4101	5096	5413
Beans	851	796	830	936

Soil characteristics

Except for pH and available phosphorus, no significant differences in soil chemical properties were observed (Table 3). The traditional treatment (T) had the lowest pH and the mechanized treatment (**ME**) the highest pH value. This is probably due to the fertilizer, which contains a certain proportion of lime as ballast. The relatively high content of available phosphorus in the mechanized treatment (**ME**) was expected because of the application of fertilizer. However, the traditional treatment (**T**) had considerably higher available phosphorus than the two semimechanized treatments (**SMB, SMNB**).

Table 3. Selected soil characteristics (1994).

Treatment	pH	OM (%)	Tot. N (%)	Avail. P (ppm)
T	3.4	6.3	0.16	10.41
SMB	3.8	6.8	0.17	9.06
SMNB	3.8	6.2	0.15	9.36
ME	4.7	6.1	0.17	12.80

Evaluation of some soil-crop management systems for sustainable crop production and environmental protection

S.Phiri and A.M.Bunyolo*

Four years of experimentation have been completed. The results so far have shown that the traditional "chitemene" system has positive effects in the first few years. The highest maize yields were produced by the high-input treatment. Due to the poor performance of Leucaena diversifolia, the agroforestry component of the low-input treatment has had no beneficial effects on crop yields. An alternative and more appropriate agroforestry species should be identified.

Site characteristics

The experiments are located at the Misamfu Regional Research Station near Kasama in northern of Zambia, approximately 800 km northeast of Lusaka. The altitude of the area is around 1400 m asl. The natural vegetation is 'miombo' woodland, with a light tree cover and thick shrub undergrowth. The annual rainfall is around 1300 mm, falling in a single rainy season of about six months, i.e. from November to April. Rainfall distribution is usually very uniform. The dominant soils in the area are Ultisols and Oxisols. They are highly leached and nutrient-deficient, with pH levels of around 4.5. The typical land-use system practiced in the area is the 'chitemene' system. It is a finger millet/cassava system based on shifting cultivation. Branches of the trees within a circle of 100-200 m are cut , collected at the centre of the field and burnt. The ashes are distributed over the plot and crops are planted. In this way, nutrients are 'imported' from adjacent areas, which are then left fallow for a number of years. With increased pressure on the land, the chitemene system is no longer sustainable.

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Experimental design

The experiments were set up to develop and test agronomically sound and economically viable soil and crop management systems for smallholders in the high-rainfall areas of northern Zambia.

The core experiment contains the following treatments:

Treatment 1 *Traditional slash-and-burn (chitemene) system* (**T1**). The system started with a mixed crop of cassava and finger millet. This was followed by groundnut, after which beans were planted until the soil was exhausted or until weed infestation became too severe. The beans were planted on mounds, and the cassava was not harvested until the third year. Light soil tillage, as practiced by the farmers, was carried out after clearing. The farmer's practice of management will be followed up to the fifth year, using the local cassava variety.

Treatment 2 *Modified (chitemene)traditional system with a crop - green manure rotation* (**T2**). The same sequence was used as that described above, except that after the groundnut an alternating system of green manure (*Crotolaria zanzibariensis*) and beans was introduced. Light soil tillage was carried out after clearing, as practiced by the farmers. An early-maturing cassava variety was used, and was harvested together with the groundnut in the second year. The beans in the fourth year will be on mounds.

Treatment 3 *Low-input continuous cropping with minimal fertilizer application and an agroforestry input* (**T3**). The cropping sequence here was maize-groundnut-finger millet-beans-beans in an alley-cropping system with *Leucaena diversifolia*. A minimum amount of lime and NPK was applied. Tree trunks were removed from the plot after clearing, and the soil was tilled with a hoe. During the first year, an application of 200 kg ha^{-1} "**D**" compound ($N:P_2O_5:K_2O:S$ - 10:20:10:9) was used as basal dressing, and 200 kg ha^{-1} ammonium nitrate was given. No lime was applied. In the second year, lime (based on soil pH) and the prunings of *Leucaena diversifolia* were applied, but no fertilizer was used. During the third year, an application of fertilizers was given as in the first year, but without top-dressing and lime. In the fourth and fifth year no fertilizers and lime will be applied, but only the prunings of *Leucaena diversifolia*.

Treatment 4 *High-input continuous cropping with optimal fertilizer application* (**T4**). The cropping sequence here was maize-groundnut-maize-beans-beans. Lime and NPK fertilizers were applied according to a rate determined after soil testing. Tree trunks were removed from the plot after clearing, and the soil was tilled with a hoe. Lime (based on Al saturation) was applied from the first year, and will continue to be applied until the fifth year. For the maize crop, an application of "D" compound at the rate of 300 kg ha^{-1} and urea at 300 kg ha^{-1} (top-dressing) was given. No fertilizer was applied to groundnut. For beans 250 kg ha^{-1} "D" compound (basal) and 100 kg ha^{-1} ammonium nitrate (top-dressing) was applied.

The experiments are arranged in a randomized complete-block design (RCBD), with four replications. The size of the plots is 20 m x 10 m (200 m^2). All cropping sequences are designed for a period of five years. During the sixth year a maize crop will be grown on all plots as an indicator crop to test the residual effects of the various soil-crop management systems. Plots were kept free of weeds at all times. Weeding was done manually.

Results

In the first year, finger millet showed that there is no significant yield difference ($P = 0.05$) between the two finger millet treatments (the traditional chitemene (**T1**) and the modified chitemene treatment (**T2**)) (Table 1). This was expected, since in the first year the treatment differed only by the different cassava varieties. The agroforestry alley-cropping species of *Leucaena diversifolia* showed relatively poor growth after one year. The biomass production was low, and therefore no prunings were applied to the second-year groundnut crop, as was planned at the start of the trial. Maize performed better in the high-input treatment (**T4**) than in the low-input treatment (**T3**), which is attributed to the fact that this treatment received a higher level of nutrients and also received lime.
In the second year, groundnut in the traditional chitemene system (**T1**) showed a significantly higher yield than the modified chitemene system (**T2**) (Table 1). This difference was attributed to the shading of the groundnut by the cassava in the modified traditional system. The early-maturing cassava grew very fast and started shading the cassava. The traditional treatment (**T1**) also gave a better groundnut yield than the low-input treatment (**T3**) and the high-input treatment (**T4**). *Leucaena diversifolia* continued to show poor growth, and therefore crops have not benefited from it either in the second or the third year . Groundnut performance in the high-input treatment (**T4**) was reasonable, but even this treatment yielded 700 kg ha^{-1} less than the traditional chitemene system (**T1**).

In the third year, all treatments had different test crops (Table 1). The growth of the beans was quite good, although the yield was low (500 kg ha^{-1}). It is suspected that the low yield of beans was due to the poor rainfall distribution during the year. The modified traditional chitemene (**T2**) had *Crotolaria zanzibariensis* as a green manure.

The growth and performance of the green manure was very good. The high biomass production is expected to greatly benefit the next crop of beans.

Table 1. Crop yield development over four years of experimentation (kg ha^{-1}).

	First year		Second year		Third year		Fourth year	
	Crop	Yield	Crop	Yield	Crop	Yield	Crop	Yield
T1 Chitemene system	F-millet	1690	G-nut	2420	Beans	460	Beans	410
T2 Modified chitemene	F-millet	1490	G-nut	1750	G-manure	1780	Beans	550
T3 Low-input system	Maize	4170	G-nut	1210	F-millet	2280	Beans	300
T4 High-input system	Maize	5100	G-nut	1720	Maize	5120	Beans	270

The low-input system (**T3**) had finger millet as the test crop. This treatment did not benefit from the *L. diversifolia* prunings as was anticipated at the start of the experiment. The average yield of 1370 kg ha^{-1} obtained is considered good in this region, but the yield could have been even higher if the *L. diversifolia* had performed better and produced more pruning material. In the high-input treatment (**T4**), the yield of maize averaged 5120 kg ha^{-1}. This yield was expected from this treatment, as the crop received the recommended fertilizer rates and also received lime in the first year. However, the results from soil analyses showed that the problem of soil acidity is slowly building up (Table 2).

Table 2. Selected soil chemical data before the start of the experiment and after two years of cropping.

			pH ($CaCl_2$)	Org. C (%)	Avail. P (ppm)	Al Sat. (%)	ECEC cmol kg^{-1}	BS (%)
T1	Chitemene	Before	4.7	1.4	32.6	7	2.8	93
		After	4.3	1.4	10.7	19	2.6	69
T2	Modified chitemene	Before	4.6	1.3	26.8	13	2.4	83
		After	4.3	1.5	15.4	25	2.4	71
T3	Low-input system	Before	4.3	1.2	28.4	24	2.5	68
		After	4.2	1.6	10.6	27	2.6	65
T4	High-input system	Before	4.4	1.4	26.31	25	2.0	85
		After	4.3	1.5	4.5	28	2.5	68

The positive effect of the traditional chitemene system (T1) was not very pronounced in the third year as the beans grown under chitemene only yielded an average of 460 kg ha^{-1}. However, the traditional chitemene system seemed to have a beneficial effect on the green manure, which grew better than in the other treatments. This was observed in the surrounding fields.

Conclusions

The traditional chitemene system (T1) had positive effects in the first few years. The incorporation of a green-manure species in this cropping system seemed to improve soil fertility (Table 2). The poor performance of *L.diversifolia* in the improved chitemene system (T2) made it difficult to evaluate the potential of agroforestry in this system. Its poor performance would certainly affect the acceptability of this agroforestry technology by smallholders. It is very unlikely that this treatment will be useful without modifications. It is hoped that another hedgerow species can be identified to replace *L. diversifolia* in the treatment.

Concluding remarks

Dr. J. Keith Syers*

This has been a useful meeting with some interesting results presented and lively discussions. At the outset, I would like to thank the contributors, both the speakers and the participants from the floor. This year, the network coordinator insisted that a report on country activities should be provided as a condition for attending the meeting. The reports have been rather variable both in terms of the quantity, and quality, but this is hardly surprising given the stage of project development (with Côte d'Ivoire having some six years of data and Nigeria only one).

I have two comments on report presentation which are offered by way of constructive criticism. Firstly, with regard to presentation, it is important to prepare in advance. We all have time constraints but there is little or no excuse for arriving at the meeting without the necessary overheads and/or slides. Secondly, with regard to the interpretation of data I believe that more effort must be made to evaluate the data which have been collected. Particularly when they are available over a period of several years.

In this context, it should be noted that in order to assess the sustainability of agricultural practices, long-term data and careful interpretation are essential. Also, when data are processed with a view to publication, interpretation is necessary. The extent of interpretation of data at this workshop has varied considerably, possibly because it is not fully realized that IBSRAM is ready and willing to assist national projects with data interpretation.

We have heard the report of the GTZ evaluation team during this meeting. I would like to thank Dr. Jürgen Blanken and Dr. Michael Bosch for their thorough review and for their constructive recommendations. This is much appreciated and, as the overall project moves into its new phase will be useful to the network, IBSRAM, and the donor.

The meeting has benefited considerably from the contribution of Professor Horst Wiechmann (University of Hamburg and representing ATSAF) and Professor Wolfgang Zech (University of Bayreuth), and I would like to thank them for their participation.

Finally, on your behalf, I wish to thank the Cameroon team, led by Mr. R. Ambassa-Kiki and the director of IRA, for organizing this meeting. Meetings such as this do not just happen; a large number of people are always involved. Our thanks are due to the members of the Cameroon team who have assisted Mr. Ambassa-Kiki and helped to make this annual meeting a success.

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* Director of Research, IBSRAM.

Closing address

Raphaël Ambassa-Kiki*

After three days hard work, accompanied by heavy rainfall, the main part of our meeting and the first phase of the *AFRICALAND* network are both coming to a close. The results obtained have been surprising for some of us, convergent for others, but at all events have been interesting to us all. I wish to thank you all for the work done, and to wish those of you who will leave the group at this stage a safe journey home. I would like to encourage the other collaborators in their efforts to plan their activities for the next project phase - despite the tight funding situation.

I would also like to express my appreciation to both IRA and IBSRAM for having organized this meeting. I wish to apologize for any inconvenience which may have been envountered on account of organizational lapses - but clearly to you. I am not very familiar with jackets, ties, and speeches, which some people may consider important on these occasions. For this reason, I would like to renew my thanks to IBSRAM for giving me the opportunity to don a necktie, wear a jacket, and make more speeches than is my normal custom.

* National Collaborator, IRA CRA Cameroon.

APPENDIXES

Appendix I

Programme of the meeting

Programme of the IBSRAM *AFRICALAND* Annual Network Meeting 15-21 May 1995, Yaoundé, Cameroon

Monday 15 May

15:00	Registration of participants	

Tuesday 16 May

09:00-09:30	Welcome address	Mr. Ambassa-Kiki, Dr. Syers
09:30-10:00	Opening of the meeting	Representative of the Ministry of Science and Technology
10:30-11:00	Introduction/background to the workshop	Dr. Zöbisch
11:00-11:30	Explanation of the workshop programmeand organizational details	Dr. Zöbisch
11:30-12:30	Report on IBSRAM activities	Dr. Syers
14:00-14:45	Land development project, Nigeria	Prof. Agboola
Chairperson:	*Dr. Safo*	
14:45-15:30	Land development project, Uganda	Prof. Zake, Mr. Nkwiine
16:00-16:30	Land development project, Côte d'Ivoire	Dr. Yoro
16:30-17:00	Land development project, Cameroon	Mr.Ambassa-Kiki Mr.Tchienkoua

Wednesday 17 May

Chairperson:	*Prof. Agboola*	
09:00-09:30	Acid soils project, Cameroon	Dr. Kotto-Same
09:30-10:00	Acid soils project, Congo	Mr. Nyete
10:30-11:15	Acid soils project, Côte d'Ivoire	Dr. Godo
11:15-12:00	Introduction to the field trip	Mr. Tchienkoua
14:00-17:30	Field trip to the IRA project site	Mr.Tchienkoua, Dr.Njomgang
18:30	IBSRAM network dinner	Dr. Syers, Mr.Ambassa-Kiki

Thursday 18 May

Chairperson:	*Prof. Zech*	
08:30-10:00	GTZ project evaluation, Part 1 (presentation, discussion, recommendations)	Dr.Blanken, Dr.Bosch
10:30-12:30	GTZ project evaluation, Part 2 (presentation, discussion, recommendations)	Dr.Blanken, Dr.Bosch
14:00-14:30	Network progress report	Dr.Zöbisch
Chairperson:	*Prof. Wiechmann*	
14:30-15:30	Introduction to new project administration rules on progress reporting and accounting	Dr.Zöbisch
16:00	Closing of the main part of the network meeting	Mr. Ambassa-Kiki, Dr. Syers

Friday 19 May

Steering Committee: Dr. Godo, Dr. Quansah, Mr. Ambassa-Kiki, Dr. Zöbisch

08:30-09:00	Project planning for MUS management of upland soils (concerned parties only)	Dr.Syers, Dr.Zöbisch
09:00-10:00	Presentation of basic data for Ghana	Dr.Quansah, Dr. Safo, Mr. Kyei-Baffour
10:30-11:30	Presentation of basic data for Côte d'Ivoire	Dr. Yoro, Dr. Godo, Ms. Yao
11:30-12:30	Presentation of basic data for Cameroon	Mr.Ambassa-Kiki, Mr.Tchienkoua, Dr.Nounamo

14:00-15:30 Planning MUS - Ghana
16:00-17:30 Planning MUS - Ghana (cont.)

Saturday 20 May

09:00-10:00 Planning MUS - Côte d'Ivoire
10:30-12:30 Planning MUS - Côte d'Ivoire (cont.)
14:00-15:30 Planning MUS - Cameroon
16:00-17:30 Planning MUS - Cameroon (cont.)
17:30-18:00 Summary of planning sessions (Dr. Syers/Dr.Zöbisch)

Sunday 21 May

09:00-10:00 Discussion of special project proposal (concerned parties only)
10:30-12:30 Discussion of special project proposal (cont.)
14:00-15:30 Discussion of special project proposal (cont.)
16:00-17:00 Discussion of special project proposal (cont.)

Appendix II

AFRICALAND Management of Upland Soils network - network steering committee

During the annual network meeting, 16-21 May 1995 in Yaoundé, Cameroon, a network steering committee was set up, and members of the committee were nominated by the national collaborators.

Terms of reference

The network steering committee will:

- assist in determining the shape and direction of the network;
- contribute to the management of the network and plan the annual network meeting;
- identify the training and information requirements of the network and assist with their implementation; and
- provide guidance for the financial management of the network.

Members of the steering committee

- The network coordinator (Dr. M.A. Zöbisch), ex officio
- Dr. G. Yoro, IDEFOR-DCC, Abidjan, Côte d'Ivoire
- Dr. E.Y. Safo, UST Kumasi, Ghana
- Mr. R. Ambassa-Kiki, IRA/CRA Yaoundé, Cameroon

Appendix III

AFRICALAND Management of Upland Soils (MUS) network - quality-assurance programme

Experience has shown that the results of laboratory analyses often show considerable inconsistencies within laboratories (i.e. over time) and between different NARS (i.e. between different laboratories). This affects the interpretation and comparison of experiments within a NARS and between the different network sites.

The proposed quality-assurance programme (QAP) aims to enhance the quality of plant and soil analyses carried out by the participating NARS. The programme will contribute to harmonizing the methods and procedures used for sampling and analyzing plant and soil samples. The QAP will also facilitate and support scientific exchange between the quality-assurance consultant and the participating NARS.

In particular the QAP will:

- monitor and assess sampling and laboratory performance of the collaborating laboratories and scientists;
- identify problems and shortfalls in sampling procedures and laboratory analyses;
- recommend improvements to the sampling and analysis procedures of plant and soil samples;
- recommend appropriate methods and procedures for sampling and analysis;
- assist in working out ways of standardizing sampling and laboratory procedures on the basis of IBSRAM's *Methodological Guidelines*;
- identify training needs for technicians and scientists;
- assist in the design of training for technicians and scientists; and
- identify appropriate laboratory equipment.

The QAP will work through:

- regular testing of standard plant and soil samples provided to the NARS;
- regular (i.e. annual) visits to the NARS; and
- regular reporting on the findings of the standard sample analysis and the NARS visits.

The agencies participating in the QAP are:

Quality-assurance consultant

Department of Plant Nutrition (Prof. C. Richter)
Institute of Crop Sciences
University of Kassel

Participating NARS

IDEFOR-DCC, Côte d'Ivoire (Dr. G. Yoro)
IRA/CRA Nkolbisson, Cameroon (Mr. R. Ambassa-Kiki)
Department of Crop Sciences. UST, Ghana (Dr. C. Quansah)

Overall coordination

IBSRAM (coordinator of the *AFRICALAND* upland soils network)

Appendix IV

Participatory rural appraisal - training workshop and village surveys

Thorsten Waibel and Manfred Beier*

Methods

The methods used for the courses served two purposes: on the one hand, they were intended to stimulate interest and activate the participation of members of the research team. On the other hand, they were also designed to transfer the current concept of self-help support. The methods included group _discussions, brain storming with visualization, plays with assigned roles, group working sessions, exercises, and practical field work.

The main method used in this workshop was 'success, weakness, aims and problems' (SWAP) which is useful for project appraisals as well as self-evaluations. If properly applied, it is especially valuable in promoting discussions between farmers, raising their awareness of existing problems and stimulating their initiatives for solving them. SWAP was originally created in Europe to facilitate the analysis of industrial enterprises by their employees. It has been established as a working tool in farmers' discussions in Nepal, Yemen, Burundi, Morocco and Tanzania, where it has been used as the standard method in several projects.

Summary of the SWAP method

SWAP is a participatory rapid appraisal method suitable for self-evaluations, for which it has certain advantages over other methods:

- SWAP promotes participation in several ways. Firstly, it encourages all community members to take part in discussions with the aim of solving problems. Secondly, the discussions focus on action and results. People who can contribute to solving

* Consultants for participatory rural appraisal.

problems are identified, and tasks are allocated to them by the community. Thirdly, by solving existing problems, the standing of the community and its members is improved. The resulting pride in achievements can lead to development processes in the community.

- The discussions of problems between the community members leads to increased awareness in the community.
- SWAP is particularly suited to stimulate the initiatives in communities for solving their own problems, and consequently differs from methods which concentrate on generating knowledge. SWAP is more of a management tool, particularly suited for informally organized groups and communities.
- By concentrating on past mistakes as a means of using them constructively for learning processes, SWAP can help communities to reduce mistakes and deficiencies.
- In contrast to many other PRA methods, which are sometimes not very rapid in their application, SWAP is fast, simple, and cheap. It is designed to concentrate on the perception and the initiatives of the participants and keep the role of outsiders to a minimum. If its different steps are strictly followed, it can be quickly understood and easily applied.

PRA-training courses in Cameroon, Côte d'Ivoire, and Ghana

The objectives of each of the three training courses were to

- enable the participants to understand the participatory approach in its theoretical context of development, self-help, and participation;
- enable them to use the instruments of PRA and SWAP methodology in their work with farmers;
- identify the problems, felt needs, and priorities of the farmers, and initiate the first steps of a participatory planning process at the village level;
- present, as far as possible, a participatory, self-help approach for research in soil management; and
- outline with the participants initial ideas and concepts about the continuation of the participatory approach within the research project.

Cameroon

The course proceeded well and its targets were fully met. The principles and methods of PRA were understood and fully accepted by the participants. Participatory planning and evaluation workshops using SWAP were practiced in two villages selected by project staff. Problems, felt needs, and priorities were identified by the farmers and the first planning steps towards on-farm-research activities were initiated by farmers and researchers.

The Cameroon researchers were made aware of the necessity for target-oriented applied research. It was noted that the socioeconomist in the group could become the main stimulus for such a reorientation if he receives sufficient support.

A participatory research approach and on-farm-research requires far-reaching changes of personal attitudes, work ethics and habits, as well as modifications in the organization of research. This cannot be achieved during the course of a single training course. To continue the adaptation and development of the new approach, a longer-term backstopping by an experienced specialist is needed. Also a regular exchange of ideas on participatory issues with other work groups of researchers, especially the group in Ghana, would facilitate the permanent establishment of farmer-oriented research.

Another precondition for sustainability is the inclusion of extension bodies in the research project. In the project area, the extension service is not very effective. An extension worker participating in the course seemed to be in this area for the first time, due to a lack of transport. His future cooperation with the *AFRICALAND* research project will only be possible if the project enables him to reach the participating farmers, preferably by making him a member of the research team. The selected villages were near and easily accessible, but they have a long history as preferred trial areas for previous IRA research projects. Farmers' scepticism about promises, their reservations about proposals, and their subsidy mentality could emerge in time, and lead to problems which require more convincing proof of the reliability of the project.

Limiting on-farm-research to 8-10 pilot farmers may be in line with small project resources (small research teams, three years of research), but it would be advantageous if the activities and experimenting initiatives proposed by many farmers during the SWAP meeting could be utilized and supported. This could be achieved by cooperation and qualitative monitoring of a second farmers' group to be included in the extension service. It would then become possible to extend the activities to additional villages using SWAP meetings. Without suitable measures, the predominant problems with parasites affecting tuber crops (termites, ants) in the selected villages could interfere with the progress of field research.

Côte d'Ivoire

The PRA workshop was initially considered by the participants as general training without specific relevance to the *AFRICALAND* research project. This was because the main contents of the on-farm research were established by the results achieved during the previous research period. The group emphasized general problems in Côte d'Ivoire with the transfer of technology from researchers to extensionists and to farmers. The group continued to be attached to this researcher-extensionist-farmer transfer model, and consequently had limited impact on farm-level development. Directive steering of development processes is seen as more important than participatory interaction with farmers, but the group's working morale and dynamism, as well as the good knowledge of the of farmers' environment and agricultural practices are hopeful signs.

During the course, and especially following the practical application of the rapid appraisal and SWAP workshop, the researchers increasingly realized the relevance of the methods for their own work. They rated the speed and efficiency of the methods used and the resulting strong interest and engagement of the farmers as being especially valuable. Due to the strong practical orientation of the researchers, sustainable impacts have been possible. However, the project's research activities should be coordinated with the farmers themselves. Backstopping on participatory research and a dynamic exchange between the project implementors in Ghana and Cameroon are recommended.

In Côte d'Ivoire, two levels of cooperation would be desirable: (i) 8-10 farmers with intensive on-farm-research, and (ii) one larger group of farmers who are visited less frequently. The emphasis should be on supporting their self-help efforts in production technologies and innovations. It is essential that the project should establish a permanent link with the extension service.

Ghana

The Ghana course was particularly productive. It took place in a very pleasant atmosphere. The methods presented were adopted quickly by the researchers, who moderated their own two SWAP workshops and achieved good farmer participation. By including the two leading district extension officers in the course, the organizers sought to link research and extension under the new methods at the earliest possible opportunity so that the objectives and methodological uniformity of the project could be assured. Also, the speedy and informal inclusion of student groups during the field phase (in farmer interviews and SWAP workshops) improved the outcome, and gave the students an excellent chance for practical work and experience.

Previous experience and the personal attitudes of the leading researchers, who see self-help and participation as very important for rural development in Ghana, made the transfer of participatory methods suitable for research an easy task. Consequently, the course focused not so much on the question 'why' to support self-help and participation but on the question 'how' to do it. The researchers' good empathy and a well-developed feeling for cooperation and communication with the farmers provided excellent starting conditions.

The focus on the research-extension linkage and the personal attitudes of the researchers provide good chances for sustainable target group oriented research activities, and the methods introduced during the course will probably be adopted. The Ghana researchers' group could make an important contribution to a research network, and consequently should be supported by both donors and IBSRAM as a worthwhile and potentially far-reaching component of the project.

Farmers' priority problems and felt needs

(xx = highest priority; x = medium priority)

Priority problems and felt needs	Country		
	Cameroon	Ghana	Côte d'Ivoire
Lack of finance for land acquisition, farm inputs, and hiring labour, high prices for farm inputs		xx	x
Declining soil fertility and yield	xx	xx	xx
Crop diseases, lack of knowledge about control of pests by agrochemicals, and agrochemicals not available		xx	
Marketing of produce is difficult (especially of perishables)	-	x	x
The majority of farmers have no contact with the extension service		x	
No knowledge on improved maize storage		x	
Climate fluctuations and lack to compensatory strategies for coffee, cocoa, food crops and vegetables			xx
Bush fires affecting coffee and cocoa plantations			x
Lack of extension for coffee and cocoa			x
Red ants cause complete failure of tuber crops	xx		
Multitude of crop parasites, especially caterpillars of plantain and banana trees	x		
Lack of knowledge of improved farming practices	x		
Cocoa plantations growing old, are not maintained and affected by brown rot	x		

Low priority problems and felt needs expressed by farmers.

Cameroon

- Low yield of groundnuts in second campaign
- Crops and vegetables which were common in the region in former times, have disappeared (i.e. tomatoes, potatoes, onions, American sugarcane)
- Good yields are only occasionally obtained
- Production of palm wine hinders other uses - for example oil production

Côte d'Ivoire

- Low selling prices for coffee and cocoa
- Theft of stocked coffee and cocoa
- Parallel marketing of coffee and cocoa undermines the cooperatives
- Termites attack coffee and cocoa
- Expensive pest treatment for coffee and cocoa
- Improved coffee-planting material is expensive
- Multiplication of coffee and cocoa by direct seeding gives poor results
- Rodents eat food crops and vegetables
- Overproduction of tomatoes
- High cost of seeds and fertilizers for vegetable crops
- Leasing of land to people from other areas
- Shortage of workers

Ghana (first village)

- Women are unable to do land clearing
- Low prices of produce due to low processing capacity and no storage
- No farm mechanization
- Difficulties in transporting produce home
- Late harvesting of maize
- No knowledge on cassava processing
- Low yields of cocoyam and lack of knowledge on cocoyam production
- No suitable storage facilities available
- Use of poor seed varieties
- Plantain disease affects young shoots
- Weeds in maize

Ghana (second village)

- Land is difficult to obtain
- Not sufficient family labour
- No fertilizer for food crops
- No manure for food crops; lack of knowledge on use of manure
- Transportation of manure is too difficult
- Diseases and pests attack vegetables
- Harvesting is difficult for large farms
- Transportation of farm produce is difficult
- Maize-cropping in short rains is not possible
- Lack of knowledge about storage
- Low yields due to shortened fallow period
- Disappearance of local cassava variety
- Vegetation changes to imperata grassland
- Loss of confidence in extension service
- Government policy favours cash crops

Appendix V

AFRICALAND Management of Upland Soils network

Michael A. Zöbisch*

Summary of details for the national projects in Côte d'Ivoire, Ghana, and Cameroon

On the basis of the *AFRICALAND* Management of Upland Soils (MUS) network document, the hypothesis, expected outputs, and objectives of the network have been reviewed, and the national projects of the network have been revised in the light of this general framework.

For representative cropping systems, treatments were designed for on-station and on-farm experimentation (Tables 1 to 8). In line with IBSRAM's *Methodological Guidelines*, the types of field observations, sampling routines, and laboratory analyses required for the experiments were identified (Table 9). To structure project activities and to facilitate match between the national projects, a general project workplan was developed which can easily be adapted to the needs of individual projects (Figure 1). As a general overview and guideline for the project, a network summary matrix was developed, which summarizes the major components of the network and the projects (Figure 2).

Hypothesis and expected outputs at the network level

Experience and previous research clearly indicate a need for nutrient input to achieve and maintain sustainable levels of agricultural production. This entails aspects of nutrient input and nutrient cycling, the efficiency of nutrient uptake by plants or plant associations, and the reduction of nutrient losses. With regard to nutrient input the main question concerns the minimum spectrum of required nutrients and the form which these nutrients should take in order to achieve and maintain sustainability at current

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yield levels. This means we have to know how external inputs can be optimized and adapted for different cropping systems and expected yield levels.

There are also important interactions between soil moisture, and nutrient transport within the soil, and also interactions which affect the nutrient uptake by plants. Soil moisture limitations during critical stages of plant development can have significant effects and influences on crop performance. Competition of weeds for nutrients, soil moisture, and light are other important issues to address.

These interactions can have positive as well as negative implications. It is therefore important to optimize them in a positive direction for efficient use of both nutrients and moisture. Practices addressing these issues are thus key elements for soil management in smallholder agriculture, including nutrient input from fertilizers and residues, and tillage for soil moisture management and weed control. These 'guiding forces' have led to the development of the following network hypothesis:

> *Through the development and implementation of appropriate soil, water, and nutrient management practices, sustainable agricultural productivity can be achieved on the upland soils of humid and subhumid tropical Africa.*

The expected outputs will benefit the land-users as well as the NARS and their staff:

- For the land-user the outputs expected from the research will constitute steps towards the achievement of sustainability at the smallholder level.
- For the land-use systems under investigation, the research will produce initial recommendations for the land users.
- Practical soil management guidelines will be available which will cover management options typically accessible to the smallholder. These soil management guidelines will provide suitable practices for tillage, organic material management, and external input which will maintain or enhance production, be economically viable and socially attractive to the farmer, environmentally suitable, and reduce the level of production risk.
- Strengthening the NARS and their scientists through research programmes and other activities will be one of the most important overall contributions of the network. Enabling and encouraging cooperating scientists to conduct research within their own institutional environment makes up a large share of IBSRAM's network activities.
- IBSRAM will contribute to the improvement of conditions conducive to research through both scientific challenge and technical support, and the cooperating scientists will have a forum of scientific exchange through IBSRAM's publications. Annual network meetings will directly expose the scientists and their work to the scientific community.
- Training on topics of scientific interest and relevance to the network will improve the quality of data and data interpretation. The NARS will benefit from improved

motivation of staff and material inputs.

- Quality control of data collection and laboratory performance through independent laboratories in Germany will also improve the performance standards of the NARS.

AFRICALAND network objectives

IBSRAM's network objectives are based on a regional perspective and extend beyond the scope of the individual country projects. They are primarily concerned with issues related to facilitation. guidance. networking. and harmonization. The objectives also encompass the activities and achievements of individual country projects. They are therefore. to a considerable degree. linked to and dependent on the individual project objectives and the extent of their eventual accomplishment.

Overall network objective

To develop and evaluate improved. alternative soil management options which are technically sound. environmentally appropriate. economically viable. able to reduce production risks. and acceptable to small-scale farmers. and which will lead to sustainable cropping.

Specific network objectives

- To assess and evaluate the needs of farmers as they relate to improved and appropriate soil management practices.
- To evaluate and assess the performance of improved cropping practices, and appropriate soil. nutrient. and moisture management methods. and their effects on sustained soil productivity.
- To establish soil management packages for the control of soil acidity and for soil fertility enhancement to ensure sustained soil productivity in permanent cultivation systems.
- To train cooperating scientists within the framework of the research and to disseminate relevant technical information with a view to strengthening the NARS.
- To initiate investigations into the acceptability of recommended technologies resulting from the research.
- To assess the sustainability of improved, alternative soil management practices through the selection and use of appropriate indicators for use with the 'framework for the evaluation of sustainable land management' (FESLM).

Hypothesis and expected outputs at the project level

For the national projects, the following generic hypothesis has been developed from the *AFRICALAND* network hypothesis.

> *Appropriate and environmentally sound soil management technologies will contribute significantly to sustainable and resource-saving smallholder agriculture in the project areas.*

Important outputs are expected at the land-users' level and at the level of NARS.

- Soil management packages will be available for large-scale validation, which will be attractive to the farmers in the project areas both in terms of their economic and their sustainability potential.
- The competence of the national cooperators and their NARS will be strengthened by research and training activities. Through the research programmes, knowledge will be gained by the cooperators from which they may develop locally appropriate soil management solutions in the future.

Project objectives

The objectives at both project level and network level are interdependent. The fulfillment of the project objectives will facilitate the achievement of the network objectives. The project objectives are location-specific. Their scope is largely limited to the immediate environment of the land users in the project area.

Overall project objective

To develop and evaluate improved, alternative soil management options which are technically sound, environmentally appropriate, economically viable, able to reduce production risks, and acceptable to small-scale farmers in the project area, and which will lead to sustainable cropping.

Specific project objectives

- To assess and evaluate the needs of local farmers as they relate to improved and appropriate soil management practices.
- To evaluate and assess the performance of locally adapted cropping systems with improved soil management practices, related to tillage, organic matter, and external

inputs at low levels.

- To evaluate the on-farm performance of selected promising soil management options
- To develop locally appropriate and applicable recommendations for soil management options for smallholders.

Table 1. Treatment description chart of on-farm experiments in Côte d'Ivoire (Abengourou), conducted with the cooperation of IDEFOR-DCC.

Treatment components	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Crop/ Cropping systems option	Major season: maize Minor season groundnut	Major season: yam + groundnut Minor season: yam	Major season: cassava + groundnut Minor season: cassava		
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice		
Organic material option	Residue left	Residue left	Residue left		
External input option	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK loc*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al		
Remarks	6-12 farmers Plot size = 100-300 m^2, depending on conditions on the farms The farmers serve as 'replicates' * major season only ** quantities revised annually				

Table 2. Treatment description chart of on-farm experiments in Côte d'Ivoire (Bécédi), conducted with the cooperation of IDEFOR-DCC.

Treatment components	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Crop/ Cropping systems option	Major season: maize	Major season: yam + groundnut	Major season: coffee + groundnut		
	Minor season groundnut	Minor season yam	Minor season: cassava		
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)		
Organic material option	Residue left	Residue left	Residue left		
External input option	NPK low*, i.e. half recommended rate	NPK low*, i.e. half recommended rate	NPK low*, i.e. half recommended rate		
	Lime** to neutralize 50% of exch. Al	Lime** to neutralize 50% of exch. Al	Lime** to neutralize 50% of exch. Al		
Remarks	6-12 farmers Plot size = 100-300 m^2, depending on conditions on the farms The farmers serve as 'replicates' * major season only ** quantities revised annually				

Table 3. Treatment description chart of on-station experiments in Côte d'Ivoire (Abengourou), conducted with the cooperation of IDEFOR-DCC.

Treatment components	Treatment 1 No. of rep.: 4	Treatment 2 No. of rep.: 4	Treatment 3 No. of rep.: 4	Treatment 4 No. of rep.: 4	Treatment 5 No. of rep.: 4	Treatment 6 No. of rep.: 4
Crop/cropping systems option	Major season: maize Minor season groundnut	Major season: maize Minor season: groundnut	Major season: coffee + yam + groundnut Minor season: coffee + yam	Major season: coffee + yam + groundnut Minor season: coffee + yam	Major season: coffee + maize Minor season: coffee + groundnut	Major season: coffee + maize Minor season: coffee + groundnut
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)
Organic material option	Residue left	Residue left	Residue left	Residue left	Residue left	Residue left
External input option	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK high*, i.e. recommended rate Lime** to neutralize 100% of exch. Al	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK high*, i.e. recommended rate Lime** to neutralize 100% of exch. Al	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK high*, i.e. recommended rate Lime** to neutralize 100% of exch. Al
Remarks	Plot size = 15 m x 20 m * major season only ** quantities revised annually					

Table 4. Treatment description chart of on-station experiments in Côte d'Ivoire (Bécédi), conducted with the cooperation of IDEFOR-DCC.

Treatment components	Treatment 1 No. of rep.: 4	Treatment 2 No. of rep.: 4	Treatment 3 No. of rep.: 4	Treatment 4 No. of rep.: 4	Treatment 5 No. of rep.: 4	Treatment 6 No. of rep.: 4
Crop/cropping systems option	Major season: maize Minor season groundnut	Major season: maize Minor season: groundnut	Major season: cassava Minor season: cassava	Major season: cassava Minor season: cassava	Major season: yam + groundnut Minor season: yam	Major season: yam + groundnut Minor season: yam
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)
Organic material option	Residue left	Residue left	Residue left	Residue left	Residue left	Residue left
External input option	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK high*, i.e. recommended rate Lime** to neutralize 100% of exch. Al	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK high*, i.e. recommended rate Lime** to neutralize 100% of exch. Al	NPK low*, i.e. half recommended rate Lime** to neutralize 50% of exch. Al	NPK high*, i.e. recommended rate Lime** to neutralize 100% of exch. Al
Remarks	Plot size = 15 m x 20 m * major season only ** quantities revised annually					

Table 5. Treatment description chart of on-farm experiments in Ghana (Kumasi), conducted with the cooperation of UST Kumasi.

Treatment components	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Crop/cropping systems option	Major season: maize Minor season cassava	Major season: maize Minor season: cassava	Major season: maize Minor season: cassava		
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)		
Organic material option	Residue left	Residue left Poultry manure 4 t ha^{-1}	Residue left Poultry manure 4 t ha^{-1}		
External input option	None	None	NPK low*, 30-20-30 (kg ha^{-1})		
Remarks	6-12 farmers Plot size = 200-400 m^2, depending on conditions on the farms The farmers serve as 'replicates' * NPK to maize (major season) only				

Table 6. Treatment description chart of on-farm experiments in Ghana (Kumasi), conducted with the cooperation of UST Research Farm.

Treatment components	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Crop/cropping systems option	Major season: maize Minor season: cassava	Major season: maize Minor season: cassava	Major season: maize Minor season: cassava	Major season: maize Minor season: cassava	Major season: maize Minor season: cassava
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)
Organic material option	Residues left	Residues left Poultry manure 4 t ha^{-1}	Residues left	Residues left	Residues left Poultry manure 4 t ha^{-1}
External input option	none	none	NPK low*, 30-20-20 (kg ha^{-1})	NPK high*, 60-40-40 (kg ha^{-1})	NPK low*, 30-20-20 (kg ha^{-1})
Remarks	Plot size = 15 m x 20 m * Maize (major season) only				

Table 7 Treatment description chart of on-farm experiments in Cameroon (Ozom), conducted with the cooperation of IRA/CRA Nkolbisson.

Treatment components	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Crop/cropping systems option	Major season: cassava + maize + groundnut Minor season: cassava	Major season: cassava + maize + groundnut Minor season: cassava			
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers' practice)			
Organic material option	Residue left	Residue left			
External input option	NPK low*, 15-20-20 (kg ha^{-1})	NPK high*, 30-40-40 (kg ha^{-1})			
Remarks	6-12 farmers Plot size = 100-300 m^2, depending on conditions on the farms The farmers serve as 'replicates' * NPK to maize (major season) only				

Table 8. Treatment description chart of on-farm experiments in Cameroon (Minkoameyos), conducted with the cooperation of IRA/CRA Nkolbisson.

Treatment components	Treatment 1 No. of rep.: 4	Treatment 2 No. of rep.: 4	Treatment 3 No. of rep.: 4	Treatment 4 No. of rep.: 4	Treatment 5 No. of rep.: 4	Treatment 6 No. of rep.: 4
Crop/cropping systems option	Major season: maize Minor season: cowpea	Major season: maize Minor season: cowpea	Major season: cassava + maize Minor season: cassava	Major season: cassava + maize Minor season: cassava	Major season: cassava + groundnut Minor season: cassava	Major season cassava + groundnut Minor season: cassava
Tillage option	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)	Hand-till (farmers' practice)
Organic material option	Residues left	Residues left	Residues left	Residues left	Residues left	Residues left
External input option	NPK low*, 15-20-20(kg ha^{-1})	NPK high*, 30-40-40(kg ha^{-1})	NPK low*, 15-20-20(kg ha^{-1})	NPK high*, 30-40-40(kg ha^{-1})	NPK low*, 15-20-20(kg ha^{-1})	NPK high*, 30-40-40(kg ha^{-1})
Remarks	Plot size = 15 m x 20 m					

* NPK in major season only

Table 9. Required field observations, sampling routines, and laboratory analyses.

Rating: 1 = required, 2 = desirable, 3 = supplementary

	Field observations	On-station experiment	On-farm experiment
Climate	Air temperature (min, max., average)	1	3
	Soil temparture (depths ..., min, max. average)	3	3
	Relative humidity	3	3
	Wind	3	3
	Radition	3	3
	Rainfall (daily. intensity)	1	1
Soil	Infiltration rate, permeability	2	3
	Surface sealing, crusting	3	3
Plants	Emergence	1	1
	Phenological stages of plant development	1	1
	Ground cover development	1	1
	Weed infestation	1	1
	Pest attack	1	1
	Disease attack	1	1
Farming activities	Clearing	1	1
	Primary tillage	1	1
	Planting	1	1
	Crop husbandry (plant protection, weeding, pruning)	1	1
	Application of fertilizers and lime	1	1
	Application of organic matter, e.g. residue, mulches, manure, etc.	1	1
	Harvest	1	1

Table 9. cont'd.

	Sampling	On-station experiment	On-farm experiment
Climate	Surface runoff (quantity, rate) (if erosion is studied)	1	3
Soil	Soil loss (if erosion is studied)	1	3
	Disturbed samples (chemical, biliogical)	1	1
	Undisturbed samples (physical)	1	2
	Soil moisture	1	2
Plants	Whole plants (above ground)	1	1
	Seeds, fruits, tubers	1	1

	Laboratory analysis	On-station experiment	On-farm experiment
Climate	Runoff nutrient content (if erosion is studied)	1	3
Soil	Nutrients, NPK, exch. bases, Al, pH	1	1
	Organic carbon	1	1
	Sediment (eroded soil) nutrients (if erosion is studied)	1	3
	Bulk density	1	1
Plants	Nutrients in exported crops/plant materials, NPK, Mg, Ca	1	1
	Nutrients in crops/plant parts remaining on the field	2	2
	Dry matter, biomass of crops	1	1
	Weeds biomass	1	1

Act No.	Activity	Subactivity	Year 1				Year 2				Year 3			
			1	2	3	4	1	2	3	4	1	2	3	4
1	Socioeconomic survey	Initial	—											
		Follow-up											—	
2	Participatory rural appraisal		—											
3	Finalization of experiments	Final site selection		—										
		Final composition of research teams	—											
4	Site characterizations	On-station		—										
		On-farm				—								
5	Preparation of sites and plots	Clearing, fencing, plot construction		—										
		Installation of facilities and field equipment		—										
		Preparation of erosion plots			—	—								
		Initiation of on-farm experiments					—							
6	Plot and crop management	Land preparation, planting, crop husbandry, harvesting			—	—	—	—	—	—	—	—	—	—
7	Data and sample collection	Climatic, soil, runoff, crop			—	—	—	—	—	—	—	—	—	—
8	Sample analysis				—	—	—	—	—	—	—	—	—	—
9	Data evaluation and interpretation				—	—	—	—	—	—	—	—	—	—
10	Farmers' days					—				—				—
11	Training	Cooperators on network basis			—				—				—	
		On project basis, e.g. students			—	—	—	—	—	—	—	—	—	—
12	Reporting	Financial reporting		—		—		—		—		—		—
		Progress reporting		—		—		—		—		—		—
13	Technical paper preparation									—	—	—	—	—
14	Final technical reporting													—

Figure 1. General project workplan.

IBSRAM network *AFRICALAND* Management of Upland Soils	*AFRICALAND* - Sustainable agriculture for humid tropical Africa		1995 - 1997
Summary of objectives/activities	Objectively verifiable indicators	Means/sources of verification	Important assumptions
Overall goal Sustainable agricultural productivity on the upland soils of humid and subhumid tropical Africa has been achieved	Crop yields in the region have stabilized	Agricultural statistics (national and FAO)	Sociopolitical and socioeconomic conditions in the region remain stable
Project purpose To develop and evaluate improved, alternative soil management options which are technically sound, environmentally suitable, economically viable, able to reduce production risks, and acceptable to small-scale farmers, and which will lead to sustainable cropping	Soil management options are taken up by agricultural extension agencies	Extension materials on improved soil management options	- Agricultural policies show prospects for smallholder agricultural development - Economic conditions of the farmers remain stable or improve - Agricultural extension agencies are functional
Results/outputs - Soil management guidelines for the control of soil acidity and soil fertility enhancement in permanent cultivation systems developed - Cooperating scientists trained in practical aspects of research and research management - Indicators for the assessment of sustainability identified - Quality control system for data collection and sample analysis established	- Soil management guidelines are known to the public and local authorities - Regular, correct and timely financial and progress reporting - FESLM can be applied to project data - Data and analyses match quality control standards	- Annual network workshop reports - Articles about research projects in the local press - Published scientific papers - Quality control reports - Project progress reports - Financial reports	- Political situation in the participating countries of the region remains stable and safe - Science administration and NARS management are supportive
Activities - Identify and characterize project sites - Conduct socioeconomic surveys - Conduct participatory rural appraisals - Collect and evaluate field and laboratory data - Establish and maintain a network data base - Provide project backstopping - Train cooperating scientists	**Resources/inputs required** - **Qualified cooperating scientists** - **Adequate transport facilities** - **Adequate laboratory facilities** - **IBSRAM's support (coordination, facilitation of workshops and publications, funds administration)** - **Cooperation from German institutions**	- Survey reports - Project progress reports - Financial reports	- Funding is secured - No significant currency devaluations take place - Cooperating researchers remain in NARS service and are motivated

Figure 2. Network summary matrix.

Appendix VI

Outline proposal for a 'special project'

Biomass management for sustainable cropping in humid areas of tropical Africa

The overall objective of the proposed project will be "to improve the soil fertility and ensure the sustainability of local farming systems through improved biomass management".

Background

Due to increasing land scarcity, fallow periods in traditional shifting cultivation systems are becoming significantly shorter. The effects on soil fertility of nutrient depletion, rapid organic-matter decline, soil acidification, and soil structural breakdown are being accelerated, and as a result natural soil fertility recoverage mechanisms are ineffective. Conventional crop and soil management technologies practiced by land-users in traditional slash-and-burn agriculture fail as increased pressures are brought to bear on the system. The proposed project will be based on the hypothesis that improved biomass management will contribute significantly to the sustainability of cropping systems in the humid tropical areas of Africa.

A largely untapped source of organic materials are weeds. Although a menace at times, certain weeds, if managed appropriately, may contribute to soil fertility maintenance in a number of ways - as a prospective mulch, as a source of additional biomass (aboveground and belowground), as a 'nutrient pump', as a source of nutrients, and as indicators of the fertility status of the soil.
The project will address these issues through biological, agronomic, and sociocultural pathways.

- Biomass production, nutrient fluxes, and soil moisture regimes of different weeds and crop-weed systems will be evaluated to assess the effects of weed integration into the soil-fertility management practices, including the effect of competition with the crop.
- The suitability of weeds and weed societies as indicators for assessing the fertility

status of the soils in the area will be evaluated.

- Farmers' perceptions and attitudes related to weeds and their relevance to soil fertility management will be evaluated to understand the sociocultural and socioeconomic circumstances determining acceptance or rejection of new soil fertility management technologies.
- *Specific criteria for the development of a practical system for the evaluation of soil fertility and sustainability under the conditions of the area will be identified.*

The project aims to address these topics using a holistic approach with multidisciplinary teams of sociocultural and socioeconomic scientists, agronomists, and soil scientists.

The project will be closely affiliated with the IBSRAM *AFRICALAND* network and its participating NARS which are a reservoir of local knowledge and experience. Both on-station and on-farm experiments will be carried out on sites which have already been established by the network. Existing research-extension linkages established by the network and participatory project monitoring will be used to test and discuss implications of the research with the farming community. The *AFRICALAND* network anticipates important new process-related knowledge from the activities which will complement the findings of the network and assist with the development of appropriate socially and economically acceptable 'soil fertility management options'.

Project outputs

The expected main outputs will be:

- Soil management options for the integration of weeds into selected cropping systems to enhance soil productivity will be developed.
- Existing methodologies to assess the sustainability of cropping systems will be refined and a list of indicators developed

Project impact

Improved soil fertility management will contribute to a stabilization of the local cropping systems and to the sustainability of agricultural land use. Feasible soil fertility management options which are socially and economically acceptable will be introduced, and small-scale farmers will be encouraged to adopt some of these options.

Working principles

All studies and experiments will be carried out in areas and on sites which are already included in the IBSRAM *AFRICALAND* network. Thus the studies will expand the scope of IBSRAM's network activities and are expected to yield valuable additional information. The on-station experiments will be set up as completely randomized blocks with four replicates, and the on-farm experiments will be located on selected and representative farms.

The project duration is expected to be three years, with a possible extension for activities which may be required as a result of the outcome of this project. The project will be fully integrated into the IBSRAM *AFRICALAND* research network structure. The research will be carried out jointly and concurrently by all the teams involved, and the expected outputs will be the result of shared efforts and responsibilities. Counselling will be provided by the entire IBSRAM *AFRICALAND* network through the network steering committee.

Project progress will be reviewed annually at the *AFRICALAND* annual network meetings. At the end of the project a symposium will be organized by IBSRAM to discuss the research findings with a wider professional audience before the final publication of the findings.

Appendix VII

A farmer's appraisal of IBSRAM's work in Uganda

After more than three years of close collaboration with the IBSRAM research team in Uganda, Mr. Y.S.M. Kasule, a small-scale farmer, summarizes his experiences. Mr. Kasule has actively participated in the IBSRAM research project and has been the link between the research team and the farmers of the area. He was also instrumental in organizing regular farmers' days at the research site, and his role in helping communication between the farmers and the researchers has contributed significantly towards the success of the project and its acceptance by the local farming community.

Ugandan farmers know little about the work of researchers. When some farmers from our district and myself visited the IBSRAM plots for the first time, we were impressed by what we saw. The research team took us around the research plots and explained the different land management practices and the performance of these practices.

We were encouraged to ask questions and to give our views. The answers and explanations given by the scientists were very useful to us, and since then we have had a number of field days. Many farmers in our district have learnt a great deal about better land management - one of the most interesting lessons being how much fertile soil is washed away by erosion if we do not protect our land. A great deal of soil fertility is lost in this way, so it is no wonder that our crop yields go down steadily if something is not done to stop soil erosion. From the IBSRAM experiments, we could clearly see the benefits of good soil cover. We are now beginning to apply this practice to our own fields, and would already be very happy if we could maintain the present level of yields and not lose more and more every season.

I would like to thank the IBSRAM research team in Uganda for allowing me, as farmer, to participate in their work. I have not only enjoyed working with them, but they have also given me and my fellow farmers many new ideas. The research team has encouraged us to think more about possible improvements rather than simply to carry on in the way we have always worked. I will try my best to see that I pass on the information and experience gained from the IBSRAM research scientists to my fellow farmers. I will also ensure that the scientists are made aware of our problems and needs so that we may benefit as much as possible from the research.

Appendix VIII

List of Participants

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