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FERTILIZER USE AT THE VILLAGE LEVEL: CONSTRAINTS AND IMPACTS

Summary Proceedings of Workshop

Lomé, Togo
October 2-8, 1991

IFDC

Fertilizer Use at the Village Level: Constraints and Impacts

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Organized by

International Fertilizer Development Center - Africa

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Editors

K. Acheampong
E. R. Rhodes
D. Pouzet

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International Fertilizer Development Center
P.O. Box 2040
Muscle Shoals, Alabama 35662, U.S.A.

Telephone: 205-381-6600
TWX-810-731-3970 IFDEC MCHL
Telefax: 205-381-7408

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Preface

The Fertilizer Investment for Soil Fertility Restoration Project (SFRP) workshop on "Fertilizer Use at the Village Level: Constraints and Impacts" was held in Lomé, Togo, October 2-8, 1991. It was jointly sponsored by the International Fertilizer Development Center-Africa (IFDC-A), Centre de la Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), the World Phosphate Institute (IMPHOS), and the American Phosphate Foundation (APF).

The objectives of the workshop were threefold:

1. To review the methodology used in the agronomic and socioeconomic studies of the SFRP.
2. To review preliminary results and problems encountered in the implementation of the project.
3. To review a draft proposal for a followup project.

Forty-two participants including industrialists, policymakers, soil scientists, agronomists, rural sociologists, economists, extension specialists, and rural development professionals drawn from international research centers, national research and extension systems, and the fertilizer industry were in attendance. The following West African countries were represented: Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Mali, Niger, Nigeria, Senegal, and Togo. Also represented were CIRAD, the French Ministry of Cooperation, IMPHOS (Morocco), APF (Canada), and IFDC (U.S.A.).

Participants spent the weekend of October 5 in northern Togo where they inspected some ongoing agricultural development projects and on-farm trials and held discussions with farmers in the SFRP experimental village of Naki-Est.

There was strong consensus among workshop participants that the achievements of the project, after 3 years of field work, point to the need for continued donor support. It was also agreed that if West Africa, and for that matter the rest of Sub-Saharan Africa, is to develop a more productive, sustainable, and equitable agricultural sector, while enhancing the natural resource base, it cannot afford to ignore fertilizers and small-scale farmers.

Participants reiterated the need to pay particular attention to the conservation of soil in the followup project, especially in those villages where soil fertility has been restored. And in doing so, emphasis should be on the use of indigenous conservation practices. It was also suggested that technologies for evaluation in the proposed project should be simple and inexpensive to enhance their adoption by farmers. The workshop also emphasized the importance of developing a data base, including an annotated bibliography on plant nutrient management technologies that cut across linguistic barriers, to improve the quality of research. Overall, the workshop helped to underline what can be accomplished through the collaborative effort of industry, donors, and international and national research and extension systems.

We are greatly indebted to M. Connolly, J. Sedgo, E. Ayuk, K. Adodo, and I. Anthony for their assistance in putting together this document. The editing of the manuscripts was done with two major guidelines: (a) to be as error free as possible and (b) to economize space wherever possible without sacrificing the ideas and opinions expressed by the authors. These proved to be formidable tasks because of the language mix and the styles presented by the various authors. It is hoped, however, that any mistakes made are minor and will not obliterate the importance of this document, which includes fostering stronger linkages between research and development professionals and policymakers in the subregion.

Editors

Abstract

Growing population densities and increased intensity of land use in West Africa have shortened the bush fallows of traditional shifting agriculture in many areas to the extent that, unless external sources of plant nutrients are added to the soil, other efforts to improve agricultural productivity will not be successful. Thus, the challenge to agricultural development professionals and policymakers in the subregion is how, not whether, to step up fertilizer use on a sustainable basis with minimum adverse effect on the environment. In response, IFDC-Africa has embarked on a Soil Fertility Restoration Project (SFRP) to study the viability of using soil amendments and fertilizers as investment strategies to restore and maintain soil fertility. The ultimate goal is to increase the availability of food, increase rural incomes, and promote agriculture and rural development through the reclamation and conservation of fertility-depleted croplands.

This document contains summary proceedings of a workshop held in Lomé, Togo, midway in project implementation, to review the methodology and preliminary results of SFRP interventions in three contrasting agroclimatic zones of West Africa. The three papers in Part I deal with the role of SFRP in agricultural development in the subregion within the context of national agricultural development policies and priorities. Papers in Parts II and III focus on the methodology and preliminary findings of the agronomic and socioeconomic research of SFRP. Country reports on the achievements and problems encountered in project implementation are presented in Part IV. These reports indicate that proper use of fertilizer credit and education to increase crop output and thereby generate even small amounts of income for the rural poor may not only open their minds to believe they themselves can change and improve their well-being, but may also lead to projects that benefit the entire rural community.

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Welcome Address

A. U. Mokwunye, Director, IFDC-Africa

It is a great pleasure to be able to welcome you on behalf of our President and Chief Executive Officer, Dr. P. J. Stangel, as participants to IFDC-Africa's first workshop on "Fertilizer Use at the Village Level: Constraints and Impacts." We are very honored that a representative of the Honorable Minister of Rural Development and the Environment and such an array of experts, including policymakers, industrialists, researchers, and development professionals from sister African countries and beyond, were prepared to set aside time to share some of their accumulated wisdom with us.

As some of you are already aware, IFDC-Africa is the West African regional center of the International Fertilizer Development Center (IFDC), a non-profit international research and development organization with headquarters in the United States of America. IFDC's worldwide mission is to undertake research and provide assistance, advisory services, and training for the transfer and use of improved fertilizer and related technology, while conserving the natural resource base and the environment. In this regard, IFDC has been an active collaborator with many national and international agricultural research and extension institutions in Africa, Asia, and Latin America.

IFDC-Africa was established here in Lomé, Togo, to consolidate IFDC's research and development efforts in West Africa in particular, and sub-Saharan Africa in general, and to initiate new programs in fertilizer marketing, policy analyses, use of indigenous agro-minerals, agronomic research, and regional information services in support of fertilizer technology transfer.

IFDC-Africa recognizes the need for training in all aspects of fertilizers with due recognition of the uniqueness of the African environments. Our training programs are geared to developing the needed human capital to promote the institutional maturity required to sustain our research and development efforts on the continent. In this regard, we operate with the firm conviction that we can only be successful if we work hand in hand with the considerable expertise lodged in the national research and extension systems.

The ultimate goal is to build and strengthen the technical and managerial capabilities of fertilizer sector personnel in the subregion through training and information sharing based on the network concept. The West African Fertilizer Management and Evaluation Network (WAFMEN) involving research and extension personnel from 14 West African countries is one of three networks already developed at IFDC-Africa.

The Soil Fertility Restoration Project (SFRP) we are going to discuss in the next few days draws heavily on several years of experience and data gathered through the activities of WAFMEN.

The rationale for initiating the project is relatively simple. Despite the significant role fertilizers have played and continue to play in agricultural development in the developed world and some parts of the developing world, fertilizer use in sub-Saharan Africa is extremely limited. Yet, with a steady decline in per capita crop production in the region, and the increasing population pressure on the fragile environment, it is clear that some form of nutrient restitution has to be made if soil fertility is to be restored and maintained for the benefit of the present and future generations.

It is against this background that, in 1987, IFDC embarked on SFRP in three contrasting agroclimatic regions of West Africa to field-test the agronomic, socioeconomic, and environmental consequences of fertilizer use at the village level and to formulate policy recommendations that will stimulate fertilizer use in the subregion. Under the best of circumstances, several years elapse (even decades sometimes) between when an agricultural technology is introduced on the scale of the SFRP and when the impacts begin to show on farmers' fields and homes. However, I believe you will learn, during this workshop, of some of the modest advances that we have already made in the past 3 years of field work.

Once again, on behalf of the President and Chief Executive Officer of IFDC, I would like to welcome you and express our sincere gratitude to the Government and people of Togo for the hospitality they continue to extend

towards IFDC. I would also like to recognize the donors for this important endeavor, the United States Agency for International Development (USAID), the World Bank, the American Phosphate Foundation (APF), the World Phosphate Institute (IMPHOS), Centre de la Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), and the Rockefeller Foundation. Representatives of some of these organizations are participating in this workshop, which demonstrates the importance they attach to the work being done with their support. I trust that when you are ready to return to your home countries and workplaces after your deliberations, you will leave with the same warm feelings and goodwill towards this country that we at IFDC have developed during our residence here.

Thank you.

Opening Address

L. K. Allaglo, Representative of the Honorable Minister of Rural Development and Environment, Togo

Honorable Director of IFDC-Africa, Honorable Representatives of the International Donor Community, the American Phosphate Foundation, IMPHOS, and CIRAD, Honorable Delegates, Distinguished Guests, Ladies and Gentlemen.

The Minister of Rural Development and Environment, the Honorable N'Koley Koffi Abotchi, wanted to grace, by his presence, the opening ceremony of this workshop, the theme of which is of crucial significance for our countries.

However, owing to some constraints arising from his schedule, he has done me the singular honor to represent him here in order to wish you a cordial and a warm welcome to Lomé, convey to you his message of support, and express his full acknowledgement to IFDC, as well as the entire international donor community represented here, for their much appreciated contribution through the unrelenting efforts they have undertaken towards the agricultural and socioeconomic development of Togo.

It is a pleasure and an honor for me to welcome you to Togo. We invite you to feel at home despite the modest facilities we have placed at your disposal as well as the numerous lapses which you will certainly note in our reception during this period of profound changes in our country.

Togo is proud of the honor which you have done her to host this workshop on the restoration of soil fertility.

As you know, agriculture employs about 75% of Togo's population; it accounts for a third of our gross domestic product and 30% of our export earnings. Its socioeconomic importance largely justifies the need to improve farming techniques and increase productivity in order to raise the standard of living of our rural communities.

These objectives can be attained by adopting innovations such as adequate use of plant nutrients and other cultural practices widely accepted as effective means of increasing crop yields. Introduction of fertilizers in crop production is certainly one factor whose immediate impact is widely recognized in most developing countries.

We are therefore delighted about your concerns because they are related to the attainment of a number of objectives, the most urgent of which is to eradicate poverty from the midst of the majority of our people.

A comprehensive analysis of the level of rural development in Togo shows that the fundamental objectives have not been achieved, especially in the field of agricultural research and rural development. In the light of this, any initiative aimed at accelerating the promotion of rural development will be welcomed by the transitional Government of Togo in view of the numerous problems facing our agriculture, all of which require urgent attention.

It is superfluous to emphasize that the conditions of human existence depend on the potentialities of the soil from which we derive the necessary items to feed, clothe, and shelter ourselves.

At a time when the population of developing countries is expanding at such a fast rate, it is practically impossible to provide their increasing food requirements without encouraging the rational management of soils. For us in Togo, it is becoming increasingly obvious that the development of agricultural production can no longer be based on expanding the area of land under cultivation but rather must be based on enhancing productivity through the use of fertilizers and effective management of soil fertility. In this regard, the role of IFDC is crucial.

Indeed, during the past 10 years, the Ministry of Rural Development has collaborated effectively with IFDC through the National Soil Research Institute in research work on the use of fertilizers in Togo within the framework of the West African Fertilizer

Management and Evaluation Network (WAFMEN). Therefore the SFRP is recognized as the logical phase for transferring to the farming community the experience acquired through WAFMEN at the various stations.

Preliminary results from the SFRP suggest that not only have significant yield increases been recorded in the village where the project was implemented but also a steady transformation is taking place in the socioeconomic environment of the participating community.

I therefore wish to express our gratitude for the assistance you have provided these farmers. We are informed that the first phase of the project will end a year from now. Permit me to suggest that the group of experts who are assembled at this meeting including pedologists, agricultural extension experts, sociologists, economists, representatives of the fertilizer industry, and policymakers will use the opportunity not only to undertake a critical evaluation of the achievements and the problems encountered, but also to draw up guidelines for a second phase of the project. We hope that the followup project will necessarily include a component of soil conservation because, as you are aware, population expansion and the corresponding increase in demand for food lead to higher demand for arable land. Consequently, farmers will be required to use land resources more intensively.

I wish to take this opportunity once again, on behalf of the Honorable Minister for Rural Development and Environment, to thank the entire international donor community and the fertilizer industry for their effective and efficient contribution, which reflects their concern to help our young national institutions; we wish to continue to rely on your logistic support.

We extend our gratitude to IFDC for the generous and steady assistance it continues to provide our countries in the field of agricultural research and development. We have always rightly appreciated this assistance as effective and useful. We wish to continue to rely on your expertise.

Distinguished delegates, may I conclude by stressing once again how much we wish your stay with us to be as pleasant as possible. However, since our material resources are very modest, we appeal to your indulgence to bear with whatever shortcomings you will certainly live with throughout your stay in Lomé. Finally, while fervently wishing you success in your deliberations and trusting that the outcome of the workshop meets the expectations of the rural community, I declare open the workshop on "Fertilizer Use at the Village Level: Constraints and Impacts."

Long Live International Cooperation

Long Live Togo

Thank you.

Keynote Address

A. Riedacker, Director, French Ministry of Cooperation, Paris, France

Honorable Director of IFDC-Africa, Ladies and Gentlemen, permit me to welcome you all and thank you, Honorable Director, for having invited me to chair this first session of your workshop.

In fact, in the French Ministry of Cooperation we hold the view that improving and restoring soil fertility are very important activities. The satisfaction of a wide range of ever-increasing basic needs depends on these activities. Permit me to mention briefly some of these needs.

Food Requirements

The world's food requirements, and in particular those of the African continent, will inevitably increase. However, some regions are already experiencing food shortages or imbalances. The intensification of agriculture will become necessary in the short-run in the subregion.

Renewable Materials and Sources of Energy

It will also become necessary to increase the amount of raw materials, energy, and other substances that agriculture can provide on a large scale. It is therefore necessary to learn how to produce them on a sustainable basis without causing damage to the environment.

The Environment

In the area of the environment, in particular, your community needs to improve its message and focus the attention of decisionmakers, the general public, and the media on the pressing need to restore soil fertility.

The general public in the industrialized countries of the North has often focused attention both on the excessive or unreasonable use to which nitrogen fertilizers are sometimes put, considering the fact that they are capable of polluting groundwater, and on the problem of agricultural surpluses, which of course has influenced the media of the entire planet. However, more often than not, the public is unaware that in Europe an average of about 200 kg/ha of fertilizer is applied annually, whereas in Africa about one-twentieth of that quantity is used (less than 10 kg/ha).

Although in some cases fertilizer use is excessive in the industrialized countries, it is rather their insufficient use that characterizes farming in Africa. Even though you are aware of this fact, we must repeat it continuously.

Preventing Soil Erosion

Nobody can challenge the fact that it is necessary to control soil erosion. Concern about this should be felt constantly by those wishing to establish lasting agricultural systems (in the sense given to this term by the Brundtland report), that is, systems that are not harmful to the environment and do not endanger the possibility of the same lands being used by future generations to feed themselves.

Indeed, the use of soil amendments, especially fertilizers and organic matter (complemented by soil microbiology and fauna such as mycorrhiza fungi, biological nitrogen fixation, or earthworms), contributes to the preservation or restoration of soil fertility. It therefore limits soil erosion directly by improving soil structure and indirectly by ensuring that erosion-prone zones are not brought under cultivation.

Besides, as you are aware, very often the restoration of soil fertility is not solely contingent on the use of nitrogen fertilizers. As was rightly pointed out by Mr. Christian Pieri, African soils are generally deficient in phosphorus. However, unlike nitrogen, phosphorus is not very mobile in the soil and is therefore unlikely to pollute groundwater.

Reducing Emissions of Gases/The Greenhouse Effect

The two environmental problems that I have just mentioned and that must be reiterated continuously are familiar to you. The same is perhaps not the case with regard to the relationship between your activities and the efforts to curb the intensification of the greenhouse effect.

The greenhouse effect, without which our planet would be much colder, is mainly due to the contents in the atmosphere of water vapor, carbon dioxide and oxides of nitrogen, and the presence of a number of other gases such as methane, carbon monoxide, etc. that absorb infrared radiation which is converted to heat. Over the past century, the increase in the atmospheric content of these gases as well as the degradation of the protective ozone layer by chlorofluorocarbons (CFCs) has made climatologists apprehensive about the greenhouse effect, which could slightly warm the planet, change rainfall patterns, increase the frequency of tornados, raise the sea level, increase coastal erosion, and probably intensify drought in some areas [1].

Combatting these climatic changes therefore presupposes that efforts would be made to curb the emission of gases that are capable of disrupting the tenuous energy balance of our planet, especially carbon dioxide [2] resulting from two primary sources:

- The use of fossil fuels or peat stored in the earth's crust.
- Changes in land use leading to the reduction of the biomass stored in plants (during deforestation) or of the carbon stored in the soil organic matter.

As in the industrialized countries, farmers who adopt soil improvement practices and use soil amendments can increase the productivity of their farmlands. Increased productivity would help to decrease the need for new farmlands and thus would alleviate the pressure on marginal and fragile lands. This intensification should be accomplished with the least possible pollution of water and the atmosphere [3].

All these concerns show how important it is to gather all types of information as you have already been doing in the pilot stations of "the experimental ecodevelopment zone." I do not intend to go into the details of the greenhouse effect issue. This issue is central to the preoccupation of both the Intergovernmental Panel on Climate Change (IPCC), and the Intergovernmental Negotiation Committee (INC) for the drafting of a convention on climate to be submitted to the United Nations Conference scheduled to take place in Rio de Janeiro in June 1992 [4] and the "Global Environment Fund" (GEF) set up at the World Bank to meet, by providing grants, the excessive costs arising from dealing with these issues.

However, the intensification of farming can also result in the production of more bio-energy from biomass, wood, oil, straw, grass, etc., which can be used as substitutes for fossil fuels. This in another respect makes it possible to contemplate reducing the emissions of carbon of fossil origin; however, it remains to be seen how far this is possible without any harmful effects on the atmosphere or groundwater.

Notes

1. Ongoing research by the Intergovernmental Panel on Climate Change (IPCC) is aimed at (a) a better understanding of the phenomena involved, (b) identifying more precisely the possible consequences, and (c) identifying the measures that would make it possible to curb global warming. Your participation in the AFOS Sub-Group (Agriculture, Forest, and other activities) of the IPCC would be highly appreciated.
2. As well as:
   - Methane emitted by gas deposits, flooded rice fields, landfills, and combustion in situ from biomass, especially through fires in savannas and forests.
   - Carbon monoxide released as a result of incomplete combustion, especially of biomass; this should in no way be likened to combustion in furnaces, which generally produces considerably smaller amounts of this pollutant.
   - Oxides of nitrogen discharged through combustion but also by nitrogen fertilizers under some circumstances.
3. See our paper titled "Reafforestation or Intensification of Farming to Combat the Intensification of the Greenhouse Effect," presented at the 5th Congress of the EEC, Biomass for Energy, Industry and the Environment," Athens, April 1991, 5 pp.
4. Refer, for useful information in this regard, to "Energy, Wood, Environment," Bulletin No. 182, published by CRES (BP 1872, Bamako, Mali).

In order to capture more carbon from the atmosphere, it is also possible to envisage the afforestation of some lands or interplanting crops with trees on farms as an agroforestry practice. It should however be emphasized that, as long as no headway is made in increasing the productivity of farmlands, the availability of new lands for afforestation will remain limited. Your activity is therefore also very crucial as far as the problem of the greenhouse effect is concerned.

However, this obvious fact needs to be pointed out to those who only think about afforestation, which of course should not be neglected whenever land is available. I only wish to enlighten you here on a number of aspects and on the fact that the restoration of soil fertility has hitherto not received the attention it deserves from those who are concerned with the threat posed by climatic changes. You will certainly play a very useful role by including this issue in your activities.

However, for your efforts to be truly effective, it is not enough to possess an in-depth knowledge of a number of biological functions and be in a position to propose new soil fertilization guidelines. It is also necessary to understand how these ideas can be disseminated, because for any type of new product to have a chance of success on the market, a number of rules must be observed:

- The location of the market and the real demand of customers and product quality should be determined. As far as quality controllers are concerned, the product should not necessarily be the best but rather the one that can provide the required service at the least cost while taking into account both the purchasing power of users and their habits.

- It should also be determined how this demand can be met, in other words which services (credit facilities advice, insurance against weather hazards, establishment of agreements or barter schemes etc.) should go hand in hand with the products being proposed.

- Finally, a specific analysis should be conducted to find out why in some cases no markets exist for fertilizers and how markets could be created.

The public authorities should sometimes formulate the necessary policies. Your role is to determine which of these policies are likely to be effective and provide the public authorities with the reasons. Your responsibility in this respect is crucial. Policymakers cannot take effective decisions unless you give them advice as well as proper guidelines to enable them to analyze situations.

I am therefore in a position to inform you that we are firmly committed to renewing our support to IFDC-Africa. The French Cooperation Agencies are aware that such research efforts are long-term efforts, which presupposes the need for adequate funding as well as evaluation of your activities on a regular basis. We hope that the other donor countries sharing these concerns will do the same.

In addition to the experimental activities that you undertake in pilot areas, the following activities will also be necessary:

- Identify what has already been achieved by other institutions, participants in this meeting who come from various African countries, research officers from CIRAD, Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM), or elsewhere. Compiling a bibliography is not only an essential task for the research officer, but generally the first of his assignments.

- Relate the results of all the activities undertaken in your field in Africa or elsewhere.

- Publish your research findings.

Permit me to stress this last point because I have often observed that research workers in Africa do not publish enough. Publishing should be done not just for the sake of increasing the number of works published but to prevent the endless process of the same work having to be started all over all the time. It is important to build up knowledge and make research findings accessible. These are the practices and conditions necessary to make progress, save time, and ensure the judicious use of financial resources allocated for research work.

Finally, it will be necessary to succeed in your activities in order to enhance not only your own confidence but also the confidence of those whose attention is focused on you as well as those who are providing the funding for your activities.

Your responsibilities and tasks, as you can see, are enormous. This explains why you cannot afford to disappoint yourselves and the larger community. The intensification of agriculture is a necessity for Africa.

An Overview of the Fertilizer Investment for Soil Fertility Restoration Project

E. R. Rhodes, Agronomist (SFRP Team Leader), IFDC-Africa, Lomé, Togo

A major constraint to agricultural production in West Africa is that the soils of the subregion are deficient in many essential plant nutrients. The deficiency of phosphorus is widespread and well known. Use of fertilizers is very low, farmers are mining crop nutrients from their lands, and food shortages and environmental degradation are predicted if present trends continue.

The Fertilizer Investment for Soil Fertility Restoration Project is a 5-year on-farm research and development project whose implementation was begun in 1988 by IFDC with funding from USAID, the World Bank, the Rockefeller Foundation, CIRAD, IMPHOS, and APF.

The long-term goal of the project is to increase the availability of food, increase rural income, and promote agricultural and rural development through the reclamation and conservation of fertility-depleted croplands. Specifically, the project seeks to assess, under contrasting agroclimatic and socioeconomic conditions in West Africa, the impact of fertilizers and animal manures on (1) restoration and maintenance of soil fertility, (2) food and cash crop production, (3) evolution in land use and farming systems, (4) the socioeconomy of village communities, and (5) the implications for reversal of environmental degradation.

The major components of SFRP's broad research and development strategy are as follows:

1. Recognition of the role of national research and extension workers and farmers in identifying constraints to crop production.

2. Multidisciplinary research conducted in partnership with farmers and national agricultural research and extension systems.

3. Integration of applied research on soil fertility management with relevant aspects of rural development.

4. Recognition of the need for extension workers and farmers to be able to continue with soil fertility restoration and maintenance after the SFRP ends.

5. Collection of socioeconomic and agronomic data on fertilizer and manure use at the farm level.

6. Use of indigenous nutrient sources wherever available.

The project is implemented in pilot areas in the humid zone of Ghana, the Savanna zone of Togo, and the Sahelian zone of Niger. Each pilot area consists of 4-5 villages within a radius of 40-50 km of the regional capital: Kumasi in Ghana, Dapaong in Togo, and Maradi in Niger. Two villages in each pilot area are designated the experimental and control villages. The experimental villages in Ghana, Togo, and Niger are Adjamesu, Naki-Est, and Tchizon Kouregue, respectively. The corresponding control villages are Hwidiem, Kpembona, and Maiguero (Figure 1).

Exploratory surveys were conducted in 1988; the main objective of these surveys was to select pilot areas and study villages in each of the three agroclimatic zones. Small-scale soil maps were used as the principal tool in the selection of the pilot areas. The criteria used in the selection of experimental and control villages included type of food crops grown, previous experience of extension workers, accessibility to and availability of large markets and fertilizer distribution depots, and fertility level of the soils in the area.

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Fertilizer/animal manure option packages (options) are evaluated on large parcels of cropland in the experimental villages. Each farmer is assigned one fertilizer/manure option, a check, and the local extension recommendation for purpose of evaluation. On-farm research trials are conducted in the experimental and control villages and two or three additional villages in each pilot area. These trials permit more in-depth evaluation of fertilization strategies.

Farm surveys are conducted annually on a sample of 60-70 farmers in each of the experimental and control villages. Selected soil, plant, and land use data are collected from the plots of these farmers annually. Soil, vegetation, and land use maps at the village level are also compiled. Rainfall in the pilot area and nitrate content of water from wells in the experimental and control villages are monitored at various times during the year.

IFDC staff based at Lomé and Muscle Shoals collaborate with staff of the Institut National des Sols (INS)/Direction Générale du Développement Rural (DGDR) in Togo, Ministry of Agriculture (MOA)/Soil Research Institute (SRI) in Ghana, and the Institut National des Recherches Agronomiques du Niger (INRAN). The day to day field activities are supervised by national coordinators with the support of a team of research/extension staff.

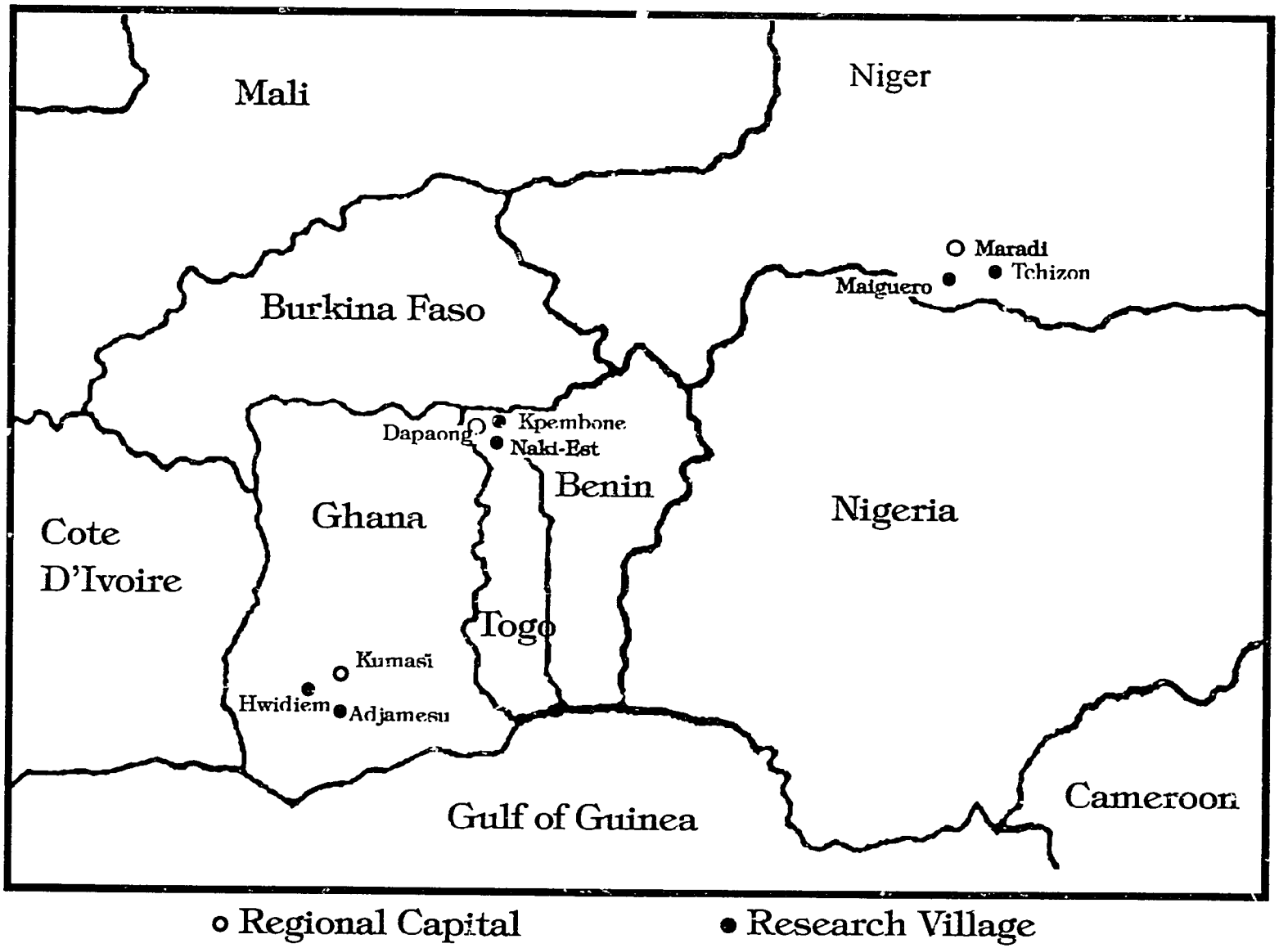

Figure 1. Location of Research Regions and Villages.

Part I: Policy Context of Fertilizer Use

Togo's Policy on Soil Fertility

The Role of the SFRP in Agricultural Development in Ghana

The Role of the SFRP in Agricultural Development in Niger

Discussion

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Togo's Policy on Soil Fertility

A. M. Gninofou, Director, Planning and Programming, Department of Rural Development, Lomé, Togo

Togo's agricultural development policy for the period 1985-90 had a dual goal of ensuring food self-sufficiency and the well-being of rural dwellers. Thus, the policy objectives were to boost agricultural production and increase farmers' incomes. This policy was guided by a development-oriented agricultural research program. Population growth dictated the introduction of intensive farming focusing on yield improvement at minimum costs while preserving the soil and its fertility.

Effects of Agricultural Policy on Fertilizer Use

The 1980s were characterized by a 2.9% annual population growth and the stagnation of food crop production (0.4%). Surplus yields cannot be envisaged in the short term because the daily per capita food production, which is 1,850 kcal, is in fact 20% lower than the acceptable minimum indicated by the Food and Agriculture Organization (FAO). Numerous activities have been undertaken to conserve soils and restore their fertility. The activities were embarked upon within the framework of Integrated Rural Development Projects with a strong emphasis on the intensification of food crop farming. The main areas dealt with under the program were:

- Promotion of the use of mineral fertilizers with doses adapted to the level of technical support and the type of crop.
- Integration of farming, livestock raising, and agroforestry.
- Improvement of cultural practices with specific actions on crop associations, rotations, schedule of fertilizer applications, and the spacing of farming cycles (maize).

Fertilizer imports rose from 18,480 mt to 36,520 mt during the decade. The trend in fertilizer imports has been irregular. The rate of unfertilized farms in 1990 was 99.7% for the Maritime Region, 87.1% for the Plateaux Region, 78.8% for the Central Region, and 45.9% for the Kara and Savanes Regions. Much effort, therefore, is still needed to increase the use of fertilizers.

Fertilizers are procured by parastatal agencies such as Service des Engrais et des Moyens de Production (SEMP) and Société Togolaise de Coton (SOTOCO). The latter is responsible for the haulage and primary distribution of fertilizers.

Secondary distribution is entrusted to agricultural development agencies such as SRCC, DRDR and other nongovernmental organizations who make fertilizers available to individual farmers on credit through farmers' cooperatives/associations. Despite its inherent advantages, this system of distribution sometimes creates difficulties in stock management, demand forecasting, procurement planning, and loan recovery.

The Government of Togo provides 25% subsidy on all fertilizers. The current wholesale price is FCFA 60/kg while the retail price is FCFA 65/kg. Removal of subsidies may lead to about 50% drop in the profit margin of maize farmers.

Research on Soil Fertility Management

Agricultural research work centers mainly on soil fertility problems; these include evaluation of mineral and organic matter levels in the soil, correction of deficiencies, and use of local plant nutrient resources.

Eight institutions (IRCT, IRCC, IRAT, INS, DRA, INTP, ORSTOM, and IFDC) are currently engaged in various agricultural research work in Togo with or without the scientific and financial partnership of Togolese research and development institutions.

Recent studies indicate that 17% of arable land in Togo is affected by degradation and is not suitable for farming. Soils in the unimodal rainfall zones, notably the Savanes, Kara, and Central regions, are deficient in phosphorus and/or nitrogen. These deficiencies have

significant impacts on crop yields. With regard to the bimodal rainfall zones, soils in the Plateaux region have been found to be deficient in nitrogen and phosphorus while those in the Maritime region are very deficient in potassium and nitrogen.

In-depth studies also indicate rapid deterioration in the fertility of croplands due to the combined effects of the decline in soil organic matter and erosion, as a result of which the soil has become acidified.

Only ferruginous soils lying on granito-gneissic platforms, brown soils on ferralitic laterites under forest, and the nondegraded "Terre de barre" maintain a satisfactory level of fertility.

Phosphate deficiencies can be corrected by using natural phosphate. Togo phosphate rock (70% acidulated) is as effective as soluble monocalcium phosphate. These research findings have led to the preparation of proposals on soil fertility improvement and maintenance manuring schemes. These schemes vary according to the various types of soils in the country.

Prospects

The Government's policy on soil fertility management and fertilizer use for the period 1991-95 is oriented toward:

- Removing constraints related to land use, taking into account the agricultural, livestock, and forestry potentials, and related human problems; restoration of soil fertility based on inputs and appropriate soil conservation methods; and training and education of farmers.

- "Redynamising" the fertilizer distribution network, improved stock management and demand evaluation; reorganization of tender procedures; and the possibility of active participation of the private sector in the procurement and distribution of fertilizers.

- Streamlining the food crop and fertilizer market by gradually reducing subsidies; establishment of credit schemes accessible to farmers; and formulating pricing policies that will ensure fair financial returns to farmers.

These have necessitated a review of the soil fertility research programs. This exercise was designed to ascertain the possibilities of maintaining intensive agriculture in densely populated farming areas, improving soil fertility, protecting the environment, and developing local resources. These laudable objectives have been designed to embrace water, soil, and plant nutrient management. The objectives are within the context of the economic profitability of the techniques proposed while minimizing the inherent risks.

The Role of the SFRP in Agricultural Development in Ghana

E. S. Otinkorang, Deputy Director,
Crop Services Department, Ministry
of Agriculture, Accra, Ghana

The agricultural sector in Ghana accounts for about 50% of GDP and 60% of export earnings. About 70% of Ghana's 14 million people live in rural areas and depend directly on agriculture. In recognition of the leading role that agriculture plays in the national economy, the Government allocates a significant proportion of the national budget to agricultural research and development.

Ghana's agricultural policy is geared toward evolving a national agricultural strategy that is oriented toward development, enhanced productivity, and the promotion of competition.

The primary role of the Ministry of Agriculture (MOA) in achieving this policy goal is to provide an enabling environment for the efficient production of food and agricultural raw materials while maintaining the natural resource base.

Cereals, root and tree crops, and legumes are grown in Ghana. Increasing population pressure and difficulty in acquiring new farmlands have necessitated a more intensive use of land. The imperative of raising yields to meet the demand of the rapidly growing population points to the need to change cultivation practices. Clearly, this will involve the use of improved seeds and fertilizers at the right time and in right quantities to ensure the sustainability of the emerging production systems.

It is against this background that the MOA readily agreed to collaborate with IFDC to implement the SFRP alongside similar agricultural development projects in Ghana, in particular, the Global 2000 and the Smallholder Rehabilitation Development Project (SRDP) funded by the International Fund for Agricultural Development (IFAD). It is pertinent to note that the objectives of the three projects tie into the Government's agricultural policy goal—increase the availability of food, increase rural income, and promote agricultural and rural development while maintaining the natural resource base.

The payoffs of this collaborative effort during the last few years have been very rewarding. In 1990, for example, Ghana exported 17,000 mt of maize to Angola. This is a significant achievement because before then Ghana was a net importer of grain.

Recognizing the important role of fertilizers in the achievement of the Government's agricultural policy objective, the MOA has embarked upon a Fertilizer Privatization Program (FPP) in order to tap the expertise of the private sector. The idea is to remove the main bottlenecks in the fertilizer subsector through the involvement of the private sector in the procurement, distribution, and marketing of fertilizers. Hitherto these functions have been performed solely by the MOA.

It is obvious that the FPP will also involve withdrawal of Government subsidies on fertilizers. This poses a great challenge in terms of fertilizer use at the village level. One would expect the farmer's natural reaction to subsidy removal and the accompanying price increases to be a drastic reduction in fertilizer use, especially in situations where the value/cost ratio is low.

Another constraint to fertilizer use is lack of credit. To address this problem, there is the need to institute a sound credit program for farmers with a built-in recovery mechanism. Many credit systems have failed because of a very low rate of recovery. Results from the revolving fund scheme instituted by the SFRP in its pilot villages

will provide useful guidelines in charting a new course in other regions of the country.

To a lesser degree, the weather also has an effect on the consumption of fertilizer. Farmers will naturally not purchase fertilizer where the weather is not favorable.

The availability of good-quality seed also contributes to the consumption of fertilizer at the village level. Many farmers will not apply fertilizer at the time of planting, as is recommended, partly because planting materials may not be available. They will only apply fertilizer after they are sure of the quality of the planting materials.

Fertilizer recommendations in Ghana are generalized; they are not site-specific. But there is a wide range of soils in Ghana, and response to fertilizer will obviously differ with soil type. There is therefore the need to develop area-specific fertilizer recommendations that bear a relation to soils in the various agroecological zones. Thus, the area-specific approach adopted by IFDC scientists in the implementation of the SFRP has been a step in the right direction. We count on IFDC through similar pilot projects not only to update but also to develop area-specific fertilizer recommendations for the remaining agroecological zones in the country.

Despite the education of farmers by our extension workers and other frontline agents on fertilizer use, some farmers are reluctant to use fertilizer. Some farmers perceive that fertilizers affect the quality of their produce, in particular the taste. This has been reported for crops such as tomatoes, maize, and cassava. It is anticipated that the followup project of the SFRP will address the root cause of this perception.

Notwithstanding some of the factors mentioned, there is an increasing awareness on the part of Ghanaian farmers with regard to the usefulness of fertilizers. It is hoped that after the initial shock waves from privatization and subsidy withdrawal, farmers will increase their consumption of fertilizer to produce more food and cash crops.

The Role of the SFRP in Agricultural Development in Niger

S. Bawa, Agricultural Director-General,
Institut National des Recherches
Agronomiques du Niger (INRAN),
Niamey, Niger

The rural sector in Niger contributes significantly to the national economy. About 85% of Niger's population undertakes most of its activities in the primary sector, which is also the main source of employment in Niger.

During the first decade of Niger's independence (1960-70), the agricultural sector played a key role in the country's development process. Toward the end of the decade, however, there was a dramatic change in the whole process due to a severe drought, decline in soil productivity, and increases in the cost of agricultural inputs.

These problems have been compounded by rapid population growth and growing demand for arable land, introduction of inappropriate agricultural practices such as "mechanised" large-scale farming, and soil erosion. Other factors, such as perennial rainfall deficits and the destruction of forests to meet the growing domestic demand for wood energy, have intensified the rate of soil degradation and desertification.

Policy and Strategies

In light of the failure of some development models pursued during the period 1973-83, a review exercise was undertaken at a national seminar, "Intervention Strategies for the Rural Areas," held at Zinder. A followup of this seminar was a national debate on desertification control held at Maradi in 1987. In the same year, an international symposium on grassroot development was held in Niamey under the theme, "People Participation and Indigenous Development."

An analysis of the policies and strategies pursued from 1960 to date leads to the following observations:

- Some policy components such as the diversification of farm produce and the organization and education of the people on their responsibilities were not backed by viable strategies and programs of action.
- The importance of such policy components was relegated to the background as mere disparate actions.

Against this background, the following policies and strategies were envisaged in order to embark on a sustained development of the rural sector:

- An integrated management of natural resources.
- Creation of a favorable legal framework.
- Organization of farmers.

SFRP in National Agricultural Development

Organizing farmers into groups is a prerequisite for making them responsible for their activities. It is against this background of harnessing the available natural resources for sustainable development through popular participation that the Government of Niger welcomed the idea of establishing a "fertilizer bank" at Tchizon Kouregue as a component of the SFRP research and development strategies. The objective of this fertilizer bank was to provide farmers in the village with a regular supply of fertilizers for the development of their farms.

In view of the important role that fertilizers play in boosting food crop production in Niger, the Government intends to strengthen this sector to ensure that fertilizers are always within the reach of farmers for use at the right time.

The project has made a significant impact in the Maradi region. It has contributed to the creation of a village management committee within the cooperative of Tchizon; the establishment of a fertilizer bank with a

working capital; significant increases in crop yields over the last couple of years; and the creation of a weekly market in the village, to mention only a few.

All these achievements were possible because of the collaboration between farmers, IFDC-Africa, and INRAN research officers to whom credit should be given.

I cannot end my presentation without thanking all IFDC donors who are making commendable efforts in restoring the fertility of our impoverished soils. In the same vein, I express my gratitude to the Director of IFDC-Africa and the Team Leader who provided me with the opportunity to be among you today. May I take this opportunity to express our profound gratitude to them.

Discussion

Mr. Akle drew the group's attention to the current debate on the effect of extensive use of fertilizers on the environment, in particular underground water. He wondered whether the project's monitoring activities cover this important aspect of fertilizer use. He also wanted to know whether some of the well-known indigenous methods of soil fertility restoration would not be more appropriate for West Africa than the use of inorganic fertilizers.

In response, Dr. Riedacker said he appreciated the concern of Mr. Akle. He indicated that, based on the outline of papers earmarked for presentation at the workshop, he is confident that the project has addressed most of Mr. Akle's concerns, and that a formal presentation would be made on effects of fertilizer use on the environment. Dr. Riedacker cautioned, however, that scientists should always guard against making broad generalizations about issues that cannot be substantiated with empirical data. He reiterated that the level of fertilizer use in West Africa (about 10 kg/ha), compared with that in other regions of the world, is such that with proper education and guidance the level can be increased fourfold without causing any adverse effect on the environment. Perhaps what is more important, he went on, is to focus on how this goal can be attained in the shortest possible time.

Dr. Gninofou shared a similar view; she emphasized that the problem of declining soil productivity is so critical in some areas of West Africa that emergency solutions are required to minimize human suffering and also to avert environmental disaster in the near future. In her opinion, fertilizers seem to have a greater promise in such critical areas than do most of the known traditional methods of fertility restoration because it appears that most of the traditional methods can no longer be sustained.

Part II: Agronomic and Environmental Considerations

Agronomic Evaluation of the SFRP Option Packages and Trials:
1. Methodological Approach

Agronomic Evaluation of the SFRP Option Packages and Trials:
2. Summary of the Results of 1989/90

Impact of Farming on the Quality of Water in West Africa:
A Preliminary Study

Discussion

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Agronomic Evaluation of the SFRP Option Packages and Trials: 1. Methodological Approach

E. R. Rhodes, Agronomist (SFRP Team Leader),
IFDC-Africa, Lomé, Togo

On-farm evaluation of fertilizer materials and animal manures in the form of option packages and trials commenced in the SFRP pilot areas in 1989. The objectives of the options were to (1) monitor and evaluate the agronomic consequences of raising soil fertility levels on a village scale, (2) generate data for economic analysis of fertilizer use, and (3) monitor crops and soil properties including organic carbon, soil acidity, and phosphorus, zinc, and cadmium status. It was expected also that the options would perform well and have a demonstration effect in the pilot areas. The on-farm trials complement the options and were designed to allow in-depth evaluation of the direct and residual effects of P fertilization strategies.

The options were evaluated in 1989 on plots ranging from 0.1 to 3 ha, according to the agroecology and resources available to the farmer. In 1990, however, plot sizes were reduced and standardized at 0.2 ha per farmer in Ghana and 0.5 ha in Togo and Niger. The options were randomly distributed among farmers. Each farmer had one option in addition to the local extension recommendation and a check plot.

As indicated earlier, the number and type of fertilizer/manure options evaluated varied with the agroecology. Local needs and availability of nutrient materials were also taken into consideration in designing the options.

The trials conducted under joint farmer/researcher management consisted of eight plots and were unreplicated per site. Trials under researcher management were laid out as randomized complete blocks, with two blocks per site. The options and trials were established on fields where farmers would normally cultivate their major food crop. Where information was available, research sites were classified according to the U. S. Department of Agriculture (USDA) Soil Taxonomy. The trials involve comparison of corrective P application versus annual P applications using a range of P fertilizer materials. The corrective P dose was estimated by the IMPHOS method (based on anion exchange resin extraction and soil texture) and the results of other workers.

Although the options were installed on the fields of all participating farmers, agronomic evaluation was restricted to the plots of a panel of 60 farmers who are involved in the annual socioeconomic surveys. The options and treatments of the trials are being evaluated mainly for their effects on crop yields, crop biomass, crop nutrient uptake, and soil properties. Manpower and laboratory facilities in each participating country determine the extent of data collection.

In addition to these data, information on crop variety, crop management, plot sizes, length of fallow, and the slope of cultivated plots are collected for each sample farmer. Monthly rainfall data in each pilot area are also collected.

Initially, comparisons were made between manured/fertilized and check plots within the experimental village; comparisons were also made between villages when feasible. Comparisons between years will be made as data for 1990 and 1991 are received and processed.

Concerning analytical procedures, descriptive statistics are used to summarize all the data collected. This is followed by least square estimation of variance (analysis of variance, covariance, and regression). The use of multivariate analysis of variance for the study of data from intercropping systems is under investigation.

The agronomic monitoring generates part of the data necessary for the economic evaluation of fertilizer use at the village level.

Agronomic Evaluation of the SFRP Option Packages and Trials: 2. Summary of the Results of 1989/90

E. R. Rhodes, Agronomist (SFRP Team Leader), IFDC-Africa, Lomé, Togo

Kumasi Pilot Area in the Humid Zone of Ghana

Baseline data in the pilot area showed that the soils were sandy loam to loam, acidic with pH of 5.4 to 6.4, low in exchangeable acidity, and moderate to high in base saturation. Plant-available phosphorus was low (Bray 1 <8 mg/kg), and organic carbon was relatively moderate (1.7%). Storage capacity for cations (cation exchange capacity) was moderate. The soils in the area are mostly Alfisols and Ultisols.

The highest mean yields in maize grain and stover in on-farm trials were obtained by applying either single superphosphate (SSP), triple superphosphate (TSP), or Togo phosphate rock partially acidulated with 50% of the H_2SO_4 required to convert the apatite to single superphosphate (PAPR-50). Corrective P application (80-90 kg P_2O_5/ha) resulted in the highest yield for both short-duration Safita (2,100 kg/ha) and full-season Dobidi (3,700 kg/ha). Yield increases over the first year of annual application of 20-30 kg P_2O_5/ha were not significant.

Data characterizing farmer practices on the option plots indicated the following: distance of plots from households ranged from 0.1 to 3 km. The age of the bush fallow ranged from 0 to 7 years, with an average of 4 years. Plant population ranged from 20,000 to 40,000 plants/ha. All the sampled farmers used an improved variety of maize; however, most of them used local varieties of cassava. The size of sampled option plots ranged from 0.2 to 1 ha with an average of 0.5 ha. Slope (gradient) of cultivated option plots ranged from 1% to 28% with an average of 7.8%. Ninety percent of farmers participating in the testing of options had plots on upper and middle slopes.

The options performed well, and results showed no significant differences in grain yields of Dobidi by using either of the following options: 80, 40, and 40 kg/ha of N, P_2O_5, and K_2O, respectively, as 15:15:15 plus urea or as Togo PAPR-50 plus urea plus KCl, and 80 and 40 kg/ha of N and P_2O_5, respectively, as SSP plus urea. Average maize grain yields on the options and check plots in the experimental village were 3,400 and 1,800 kg/ha, respectively. Maize yields from a sample of farmers in the control village averaged 2,200 kg/ha.

Maize grain yield variability in the area was mainly associated with changes in P rates and plant populations and with the age of the bush fallow. Maize grain nutrient removal (mining) per hectare from unfertilized plots over one growing season was as follows: 30.9 kg N, 7.5 kg P_2O_5, 7.7 kg K_2O, 3.6 kg CaO, and 4.3 kg MgO. Nutrient mining is a serious problem in West Africa that leads to the degradation of the soil resource base.

Dapaong Pilot Area in the Savanna Zone of Togo

The Dapaong soils were loamy sand to sandy loam, acidic with pH of 5.8 to 6.5, low in exchangeable acidity and with the cation exchange complex dominated by bases, especially calcium. Plant-available phosphorus (Bray 1 <6 mg/kg) and soil organic carbon content (0.37%) were low. Storage capacity for cations (cation exchange capacity) was low. The soils are Alfisols and Inceptisols/Entisols.

Highest total yield of 1,200 kg/ha of 6-month millet variety plus sorghum was obtained from the use of SSP at 60 kg P_2O_5/ha in the on-farm trials. Similarly, the highest total yield of 3-month millet variety + 3-month sorghum variety was 1,300 kg/ha and resulted from the use of SSP at 60 kg P_2O_5. Millet and sorghum yield variability in the trials was also associated with changes in plant population.

Fertilization increased crop biomass both above and below ground level. Total biomass from an unfertilized millet/sorghum plot was 2,800 kg/ha compared

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to 10,000 kg/ha from a plot fertilized with 60 kg N, 75 kg P_2O_5, and 35 kg K_2O/ha. About 25% by weight of crop residue on fertilized plots was in the form of roots.

There was a net export of nutrients from unfertilized plots: 6.4 kg N, 1.8 kg P_2O_5, 44.9 kg K_2O, 8.1 kg CaO, and 3.8 kg MgO per hectare were removed by millet/sorghum from a research site at Naki-Est when no fertilizer was applied (soil mining); when N and K were applied but no P, crop removal of P was greater. The extent of the depletion depended on whether only grain was removed from the field or both grain and straw, as well as the nutrient in question. At the corrective P dose (75 kg P_2O_5/ha), P_2O_5 removal by grain plus straw was 16% of that added to the soil in the form of SSP.

Distance of option plots from households ranged from 0 to 4.5 km with an average of 0.2 km. The sizes of option plots ranged from 0.1 to 3 ha with an average of 0.99 ha. Slope of these plots ranged from 1% to 4% with an average of 2.6%. Plant population was high on the option plots, about 38,000 and 50,000 plants per hectare on the average for the 3-month and 6-month millet intercrop. Local varieties of millet and sorghum were used. Practically all the plots had been under continuous cropping.

The options performed well with respect to the internal check in the experimental village and sample plots in the control village. Total grain yield from unfertilized plots intercropped with 3-month and 6-month millet varieties was 800 kg/ha in the experimental village, and 1,100 kg/ha in the control village. In the experimental village, grain yield from plots that received 60 kg N + 35 kg P_2O_5 + 35 kg K_2O/ha in the form of 15:15:15 + urea was 2,500 kg/ha.

Highest grain yields were accompanied by grain removal per hectare of 29.0 kg N, 15.2 kg P_2O_5, 14.2 kg K_2O. On the other hand, 9.7 kg N, 3.0 kg P_2O_5, and 4.4 kg K_2O/ha were removed by millet grains from the check plots in the experimental village. This compared with 12.4 kg N, 3.9 kg P_2O_5, and 5.6 kg K_2O/ha removed by grain from sample plots in the control village.

Maradi Pilot Area in the Sahelian Zone of Niger

In Maradi, the soil texture was sand and the reaction acidic with pH of 4.8 to 6.3. Exchangeable Al was insignificant in the soils of higher pH, but occupied up to 20% of the exchange sites in the soils of lower pH. Plant-available phosphorus (Bray 1 <3 mg/kg) and soil organic carbon content (<0.15%) were very low. Storage capacity for cations (cation exchange capacity) was very low. The soils are mostly Alfisols.

Highest yields obtained in the on-farm trials were 1,330 and 393 kg/ha, respectively, of millet and cowpea in intercrop resulting from SSP at 60 kg P_2O_5/ha. Millet grain yields from plots fertilized with ground Tahoua phosphate were about 70% of those obtained from the use of SSP. Grain yield resulting from the corrective P application, 60 kg P_2O_5/ha, was significantly better than that of the first year of the annual application (20 kg P_2O_5/ha). Effect of fertilization on yields was minimal for cowpea, but the level of crop management accounted for a high proportion of the variation in grain yield.

Distance of plots from households on which the options were evaluated ranged from 0.5 to 4 km with an average of 1.6 km. Plot size was 0.5 ha. Fifty percent (50%) of plots had been under continuous cropping for 10 or more years; only 7% of plots were newly cleared from fallow. The dominant cropping system was the millet/cowpea intercrop; the number of millet hills ranged from 2,000 to 7,000/ha, and the number of cowpea hills was between 500 and 4,000/ha. Extent of use of "improved" seeds varied with cropping system. On the average, 80% of plots were sown with "improved" seeds.

All the options resulted in millet grain yields that were significantly higher than the check (240 kg/ha). Highest millet grain yield of 722 kg/ha was obtained from 30 kg N/ha + 60 kg P_2O_5/ha as urea and SSP. This option also resulted in the highest total grain yield of millet + sorghum + cowpea of 1,059 kg/ha. Average yield of millet in the control village was 480 kg/ha.

Soil Pollution

Levels of extractable cadmium in soils that were fertilized with various phosphate materials were very low (below 0.5 mg/kg soil).

Impact of Farming on the Quality of Water in West Africa: A Preliminary Study

D. Pierre, Soil Scientist,
IFDC-Africa, Lomé, Togo

The ideas that we are going to express and the results that we will discuss are the outcome of a preliminary study. A scientific study on this theme would require the commitment of significant financial resources, the installation of special equipment, and, above all, the selection of the sites purposely for the study.

What is meant by water pollution? Generally, the impact of agriculture on water resources means all the changes in quality (as compared with a natural situation) as a result of agricultural activities. Pollution as a result of agricultural activities more often than not affects surface water (rivers). Because the replenishment of groundwater resources occurs slowly, the seeping of pollutants into the groundwater affects its quality over a long period. Pollution due to agricultural activities is a widespread phenomenon, and prevention alone can help avoid its harmful effects.

In West Africa, the prevention of groundwater pollution is of crucial importance. The proportion of the population that has access to treated water is low, and regardless of the climatic zone being considered, groundwater resources are the most suitable source of water to meet this challenge. They constitute a permanent source of water that is free from germs.

What Is Meant by Agricultural Pollutants?

The agricultural pollutants identified include fertilizers, human and animal waste, and phytosanitary products. Fertilizers can be a source of the high potassium (K^+), phosphate (HPO_4^-), ammonium (NH_4^+), and nitrate (NO_3^-) content of water. In practice, the nitrates alone give cause for concern. In a situation where significant quantities of nitrogen fertilizers (100-400 kg N/ha) have been used over time, nitrate concentration in groundwater resources can sometimes be higher than the standard for potability (10 mg NO_3-N/L or 50 mg NO_3/L).

Importance of Agricultural Risk Factors for the Environment in West Africa

It has been noted that a number of environmental factors can cause water pollution. Some of the risk factors are common or peculiar to the various agroecological zones under study.

They include factors such as the generally sandy texture of soils, their low water retention capacity, and overall low fertility. Among the climatic features that may be considered as risk factors are the intensity and irregularity of rainfall. Rural development also entails risks for the environment, particularly the development of human settlements and livestock pens near sources of water.

The peculiar risk associated with each of the ecological zones was examined through separate analysis of the three project sites.

Sites in the Maradi Pilot Area of the Sahelian Zone (Niger)

These sites are characterized by a rolling topography and sandy soils. Average annual rainfall of the area is about 500 mm; the rainfall is unimodal and occurs between the months of May and September. The water table is generally low (between 25 m and 50 m deep). Human settlements are grouped into fairly large villages and are usually not within the immediate vicinity of wells. Livestock are driven daily to the wells to drink.

The levels of nitrate nitrogen concentration in water samples from three wells in Tchizon and Maiguero ranged from 4 to 16 mg NO_3-N/L. However, subsequent monitoring between May 1990 and August 1991 showed

that the levels of concentration have stabilized. It is difficult to determine precisely the source of these nitrates because the groundwater is replenished from sources within and outside the village area. Probable sources may include droppings from animals that usually drink from the wells as well as the very source or origin of the groundwater. Nevertheless, our analysis indicates that the observed level of nitrogen concentration in the groundwater was too high to be attributed to the nitrogen fertilizer used by farmers in the village.

Sites in the Kumasi Pilot Area in the Humid Zone (Ghana)

The sites in the Kumasi area are characterized by eroded summits and rolling topography, with farms and patches of secondary forests along slopes. It is possible to crop twice in the year partly because the average annual rainfall of between 1,400 and 1,600 mm is bimodal. The major growing season is from March/April to July/August followed by a minor season from September through November.

The soils have a virtually permanent vegetation cover. Our assessment of nitrogen nitrate concentration in four village wells showed levels ranging from 2 to 18 mg NO_3-N/L; Only one of the four water samples had a relatively high level of nitrate concentration. However, subsequent measurements between the period June 1990 and July 1991 showed considerable fluctuations in the level of nitrate concentration in the water samples. The hydrological system of the site is shallow and may be a contributory factor. The problem therefore was to ascertain the extent to which human activities including farming and livestock raising have contributed to the pollution of the groundwater. Although from the environmental point of view the forest is the most suitable cover for the soil, it has been documented that forest exploitation or the cultivation of forest areas after burning could affect the environment through the mineralization of nitrogen in organic matter (several metric tons per hectare). In this context, the level of nitrogen fertilizers used by farmers could not have any significant impact on groundwater.

Sites in the Dapaong Pilot Area in the Savanna Zone (Togo)

Average annual rainfall of the area is 900 mm; it is unimodal and occurs between the months of April/May and October. Rainfall is either in the form of rainstorms (of the Sahelian type), or it lasts for long periods. The geomorphology of the area is characterized by eroded sandstones leading to the formation of cuestas interspersed with wide valleys. The area is also characterized by dispersed settlement patterns located mostly in the upper sections of the valleys.

Nitrate nitrogen concentration measured in water samples collected from five wells ranged from 1 to 25 mg/L NO_3-N, but only two analyses showed results in excess of the acceptable norm; the rest ranged between 1 and 3 mg/L. However, continuous monitoring from June 1990 to July 1991 revealed that the level of nitrate concentration in water increased at the beginning of the rainy season.

The hydrology of the site is complex, comprising a temporary surface network, a temporary sheet of groundwater in a low-lying area, and a year-round reserve of groundwater in the sandstones. The probable origin of the nitrate washed into wells in the drainage basin could therefore be attributed to human settlements and farming activities including livestock raising "up-stream."

Conclusion and Future Prospects

Tests conducted on water samples from selected sites in the three pilot areas of the SFRP showed the presence of some amount of nitrates. Although this could be attributed partly to farming activities, one cannot rule out possible contamination from animal and human waste because of the pattern of human settlements and pastoral activities in the pilot areas. As of now, water contamination by fertilizers is highly improbable because the quantity of fertilizer used by farmers is too low to have any meaningful impact on groundwater.

The effects of fertilizer use on groundwater remain to be seen. It is therefore important to continue the monitoring activities as farmers adopt intensive agricultural practices so as to identify the source(s) of the nitrates observed and initiate preventive measures. Concern for the quality of our environment is an important factor that needs to be integrated into agricultural production systems. The problem is an important one and requires in-depth study. Such a study should be able to come up with appropriate reliable cultural practices that would make agricultural production compatible with the preservation of water quality.

Discussion

The discussion that followed the presentations of Dr. Rhodes and Mr. Pierre focused mainly on the following: the need for simple designs in farmer-managed on-farm trials; the use of "apparent" nutrient balances; the need for monitoring agronomic variables over a number of years; the significant quantity of crop biomass resulting from fertilizer use in the experimental village in Togo; and conclusions that can be drawn from the preliminary results on the monitoring of nitrate-N levels in water drawn from wells in the SFRP pilot villages.

Dr. Rhodes explained that the evaluation of option packages managed by farmers involved a maximum of three plots per farmer. The trials that were jointly managed by farmers and researchers consisted of eight plots, including two checks, and were replicated over sites. Concerning the apparent phosphorus balance, Dr. Rhodes explained that it could be a useful tool for comparing P treatments on the same site where losses by erosion and other processes from the various treatment plots would be expected to be the same. The agronomic monitoring commenced in 1989, one year after the socioeconomic baseline survey. There was a drought in the SFRP pilot villages in Ghana and Togo in 1990, which militated against the collection of agronomic data. As soon as data for 1991 are received, comparisons will be made with the results obtained in 1989. On his part, Mr. Pierre explained that the study on the monitoring of nitrate-N levels in well water was exploratory and that the preliminary results obtained will be useful in designing a more comprehensive study.

Part III: Socioeconomic Considerations

Socioeconomic Research of the SFRP: Design, Implementation, and Preliminary Findings

Agroeconomic Studies of the SFRP: Methodology

Fertilizer Use and Cropping Systems in Niger

Discussion

Profitability of Fertilizer Use Options in Ghana

Direct and Indirect Benefits of Fertilizer Use

Farm-Level Constraints to Fertilizer Use

Labor Contributions of Women to Crop Production Activities in Three Regions of West Africa: An Analysis of Farm Survey Data

Farming Practices and Economic Profitability of Inputs on Cotton in Burkina Faso: The Research Approach

A Comment

Discussion

Socioeconomic Research of the SFRP: Design, Implementation, and Preliminary Findings

K. Acheampong, Rural Sociologist, IFDC-Africa, Lomé, Togo, and T. P. Thompson, Sociologist, Resources Management, Research and Development Division, IFDC, Muscle Shoals, Alabama, U.S.A.

Central to the socioeconomic research of the SFRP is a longitudinal study of a sample of farmers in the three pilot regions where the project is being implemented. The objective is to generate a broad range of socioeconomic data to monitor and evaluate the qualitative and quantitative impacts of SFRP interventions.

Two successive socioeconomic surveys have been conducted since the completion of a baseline socioeconomic survey in 1988, and the data are being processed for analyses. This paper provides a summary of the design and implementation of the survey, the focus of data analysis, and some observations from the baseline survey.

Research Design and Implementation

The research methodology has taken the form of "the two-group experimental design" (control and experimental groups) in the light of the duration of the first phase of the project (5 years). The objective is to limit the number of potential extraneous factors that could confound the data if the studies were limited to the experimental group. In other words, the design is intended to facilitate a comparison of users and nonusers of fertilizer on the basis of data from the experimental and control villages.

Village and Sample Selection

Two villages were chosen to represent each pilot region after an exploratory survey of a purposive sample of between six and ten villages in each region. The selection criteria included (1) agricultural population base, (2) cropping systems, (3) proximity and accessibility to large markets, (4) organization and availability of extension services, and (5) centrality of location to enhance the adoption and diffusion of information about fertilizer and other agricultural inputs.

For each of the sample villages, a sampling frame comprising all adult male and female farmers in the village was compiled, and a random sample of between 60 and 70 farmers stratified by gender was chosen. This yielded a total sample of 375 farmers including 133 women.

Data Collection and Analyses

Survey questionnaires were prepared, pretested, and revised in collaboration with counterpart staff. The questionnaires contained open and closed-end items, and were designed so that data can be classified by gender and then compared and contrasted with the baseline data to assess SFRP's impacts in the research villages.

Interviews were conducted by national collaborators under the supervision of IFDC staff. The interviewers received instructions on field survey work and interviewing techniques, including practice interviews as well as detailed discussions about the intent and nature of the questionnaires and the objectives of the SFRP. Interviews were conducted in farmers' homes, in village centers, and in farmers' fields.

The baseline survey generated data on gender; cultural groups, household location, composition, education, and employment; land availability and tenure; the use of machinery, animals, equipment, and credit; crop areas and management, including the use and cost of fertilizers, organic manures, and crop residues; disposal and use of crop production; and finally, the perceptions of farmers about constraints to fertilizer use and agricultural production.

Descriptive statistics such as means, medians, and standard deviations were used in a gender-specific analysis of the data focusing on variables that

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characterize agricultural production and the socioeconomic environment in the research villages. In addition, econometric models were used to estimate labor use, crop production, and income functions of farmers. These functions should allow the identification and assessment of changes in levels of production, productivity, income, and labor demand, among others.

Observations From the Baseline Survey

The mean age of farmers ranged from 40.6 in Ghana to 43.1 in Niger and 44.6 in Togo. The highest average years of schooling was recorded for men in Ghana (7.8), followed by Niger (2.2), and Togo (0.8). Ghanaian women also ranked first in years of schooling, about 4 years on the average, followed by the Togolese women, less than 1 year; the Nigerien women sample recorded no formal schooling. Concentration of larger households was found to be highest in Togo (11 persons on the average) and lowest in Niger (6 persons).

Ownership and, by implication, use of agricultural equipment such as ploughs, seeders, and mistblowers were found to be minimal among men in all the six sample villages; no women reported owning agricultural equipment. But ownership of handtools was virtually universal, although the average number of tools owned by men was always greater than that for women. The same principle applies to the ownership of animals.

Fertilizer use was greatest among farmers in Togo, where fertilizer credit for the cultivation of cotton has been institutionalized, and least in Ghana; however, Togolese and Nigerien men were significantly more likely than women to use fertilizers on their plots.

More than 80% of the total cropped area in the research villages consists of familial and individually owned plots. But individualization of land tenure was found to be greater in Niger than in Togo and Ghana. Women in Ghana are more likely than men to crop on family-owned plots. In contrast, Nigerien and Togolese men are more likely than women to crop on family-owned plots. Thus, the matrilineal and patrilineal systems of inheritance in the pilot areas in Ghana, and in Togo and Niger, respectively, were clearly evident from the data. Regardless of region, men were more likely than women to crop larger plots and more plots.

Farmers ranked low soil fertility, deficient rain, and pests, in order of importance, as the main production constraints regardless of region and gender. This indicates that the goals of SFRP clearly address the most important constraint to agricultural production as perceived by farmers in the three regions.

Aside from generating data that would be used to monitor and evaluate SFRP interventions, the baseline survey provided deeper insights into how project services and inputs should be tailored to meet the unique needs and aspirations of collaborating farmers.

As much as possible, the original sample of respondents was reinterviewed in the subsequent surveys. Data from these surveys will be used to (1) describe and discuss sociodemographic characteristics of users and nonusers of fertilizers, (2) measure and discuss the consequences of fertilizer use on agricultural production and socioeconomic variables, (3) assess and describe the benefits, costs, and constraints associated with fertilizer use, and (4) discuss the implications of the research findings for agricultural extension work and policy development.

Agroeconomic Studies of the SFRP: Methodology

D. Pouzet, Agricultural Economist,
CIRAD/IFDC-Africa, Lomé, Togo

The possibility of restoring the fertility of soil was examined in three ecological zones in West Africa. The research involved the application of fertilizers mainly to food crops. Agroeconomic studies were conducted to identify the constraints in the use of fertilizers. The aim was to define the areas in which appropriate recommendations could be made to address the problem of declining soil fertility. This paper provides a summary of the methods used to achieve these objectives.

The first phase involved evaluating soil fertility problems of each village. What are the main constraints and potentialities of the physical environment in which the farmers pursue their activities? To what extent can farmers grow crops in this environment to earn a living? The objective of the second phase was to assess the profit that farmers could expect from the use of mineral fertilizers.

A map is a useful tool to interpret some of the characteristics of the physical environment. With the assistance of specialized national agencies (the Soil Research Institute in Ghana, Institut National des Sols in Togo, and Services du Cadastre in Niger), land-use and other relevant data were collected and used to prepare sketch maps of the three pilot villages. The information was later processed using the Geographic Information System (GIS) to develop land-use maps, including soil types, and the location of surface water resources. Aside from providing deeper insights into current land-use patterns, these maps will serve as a useful tool in proposing alternative land-use systems that enhance productivity while preserving the environment. The maps of Naki-Est, the experimental village in Togo, are provided in the Appendix.

The capacity of the environment to sustain current farming practices was assessed through a survey. Production units (PUs) or farm households were enumerated at the beginning of the 1989/1990 crop year. Additional data were collected on factors of production (availability of labor, land, equipment, and tools); farm and non-farm activities, including number and type of animals owned and crop output; household food requirement; and temporary and permanent migratory patterns, among others. A total of 450 PUs were interviewed at different time periods during the year.

Other activities of the PUs were monitored through annual surveys that focused on but were not limited to fertilizer use. This was also initiated in 1989. We attempted, on the one hand, to evaluate the farming systems that involved the use of fertilizers (mineral and/or organic) by identifying the type of fertilizer used; the date and quantity of fertilizer used; date of purchase, place and amount paid; the type of crop and area of plots and the distance from the village to the plots on which the fertilizers were applied; and land tenure/management status.

We also examined how households meet their food requirements between two cropping seasons by analyzing expenditures on staple food crops including the date, type, quantity, and cost of food purchased. A paper based on some of the data collected is included in this volume [5].

Questionnaires were designed according to the objective of each survey. These questionnaires were based on general information arising from discussions with village leaders (1988), field officers, and a review of literature on previous work done in the pilot areas by other workers. Interviewers were trained, and the questionnaires were pre-tested before the actual farm survey. The survey was monitored daily until completion. Systematic vetting, including verification with other

Note

5. See "Fertilizer Use and Farming Systems in Niger" (in this volume).

results, was also conducted before the data were put into the computer. Subsequent surveys made it possible to verify the reliability of the data. These activities enabled us to proceed with the analysis. A survey of this nature is cumbersome, but it was necessary to group the farmers according to defined characteristics at the beginning of the project to allow a meaningful evaluation of project impacts. It also helped to identify representative samples, taking into consideration the objectives of the research, and it enabled us to verify whether or not the study sample drawn at random was representative of the entire population. In this regard, we have compiled a list of all the PUs, which will also serve as a basis to evaluate the agronomic and socioeconomic impacts of project interventions.

The data collected during the survey have made it possible to identify the variability in agricultural production systems in the villages. They have also allowed us to develop a typology of farmers according to their capacity to use fertilizers. This information has given us deeper insights into how farmers are responding to the soil fertility interventions introduced in the pilot villages. Preliminary results of the analysis of data from Niger and Togo have since been published [6]. The results have enabled us to make recommendations adapted to the peculiar characteristics of each group of farmers; the analysis will also facilitate extrapolating the data to the village level by aggregating the household data obtained.

The study of profitability of fertilizer use was based on a representative sample of farmers participating in the village-level fertilization. The analysis of the results was subject to the acquisition of economic information on the site where the studies were conducted. The value of the produce was estimated from weekly producer price surveys. Farm budget surveys were conducted in 1989/90 to collect information, including estimates of the cost of complimentary resources. The surveys covered the main food and cash crops cultivated in each pilot area: cost of labor for the various crop production activities and other essential inputs, crop output, and marketing. The sampling procedure included "pairing of plots of land" based on the application or nonapplication of fertilizers and the distance of plots from the village. A paper based on an analysis of the data is included in this volume [7].

Notes

6. Pouzet, D., and A. Pieron. 1990. Les attentes des paysans en matière d'engrais minéraux, cas du nord Togo et du sud Niger. In acte des Rencontres Internationales, "Savanes d'Afrique, terres fertiles." Montpellier 10-14 décembre 1990. Edit Ministère de la Coopération et du Développement CIRAD, Paris, p. 439-463.

7. See "Profitability of Fertilizer Use Options in Ghana" (in this volume).

Fertilizer Use and Cropping Systems in Niger

D. Pouzet, Agricultural Economist,
CIRAD/IFDC-Africa, Lomé, Togo

Data for this paper derive from the first and second series of interviews conducted with people engaged in farming in the village of Tchizon in 1989 and 1990. Both surveys involved 180 heads of households and focused primarily on mineral fertilizer and manure use during the cropping seasons of 1989 (a year after a disappointing harvest) and 1990 (a relatively good year). Preliminary analyses of the data suggest the following:

1. Mineral fertilizer use increased significantly partly because of the creation of the fertilizer revolving fund. The percentage of farmers who used mineral fertilizers increased from 38% to 98%.

2. The quantity of fertilizers purchased on credit did not always correspond to farmers' requirements, an indication that farmers probably stored varying proportions of their fertilizers for future use.

3. Seventy-six percent of farmers used organic fertilizers, but this was applied to only 27% of the total area cropped.

4. In times of food shortages, women are virtually excluded from decisions concerning the use of mineral fertilizers; women represent only 1.2% of mineral fertilizer users.

5. During periods of food scarcity, family-owned farms (over 95% of the cases) tend to be more important to farmers than individually owned farms in terms of mineral fertilizer use.

6. During periods of food surpluses, mineral fertilizers are more often used on farms owned by individuals (26%) and also by women (12%).

7. In periods of food surpluses, organic manure is used only on family-owned farms (100%); such farms are usually managed by men (99.7%).

8. Mineral fertilizers and manure are used as a matter of priority on farms that are nearest to the village. Consequently, intensive farming is undertaken within a 2-km radius of the village. About 90% of manure and 73% of mineral fertilizers were used in this zone (Figure 2).

9. Another zone of intensive cultivation involving use of mineral fertilizers occurs within a 2.5- to 3-km radius of the village; this is probably due to "overcrowding" on the first zone.

10. Farms located more than 3 km away from the village are fertilized only in exceptional cases. Quite often, they are cultivated extensively without adequate soil preparation, and are usually not well maintained. This zone extends into shrublands, which are used mainly for agro-pastoral activities.

11. Manures are preferably used on farms that are closest to the village partly because, compared to mineral fertilizers, they are more difficult to transport over longer distances.

12. Areas under sole crops to which mineral fertilizers are applied account for 30%-35% of the total area fertilized. Mineral fertilizers are therefore applied on farms with mixed cropping systems. Nine major types of such farms with about 50 crop combinations were observed.

13. Food crops such as millet, sorghum, groundnut, and cowpea are fertilized as a matter of priority to assure production of sufficient basic food supplies to meet family needs. Food crops covered over 82% of fertilized farmlands and received 79% of fertilizers applied.

14. Once the food crop requirements have been met, farmers turn their attention to cash crops. Thus, the area seeded to cash crops (26%) received 44%

of the total fertilizer used compared to 40% for cereals and 16% for legumes.

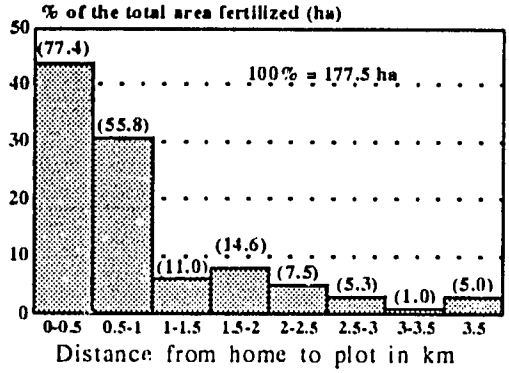
15. The dosage of mineral fertilizers used on cash crops was much higher than that on the other crops. For instance, in 1990, plots seeded to souchet/tiger nuts *(Cyperus esculentus)* as sole crop received an average of 247 kg/ha of simple superphosphate and 128 kg/ha of urea compared to 111 kg/ha and 70 kg/ha, respectively, for sole crop millet.

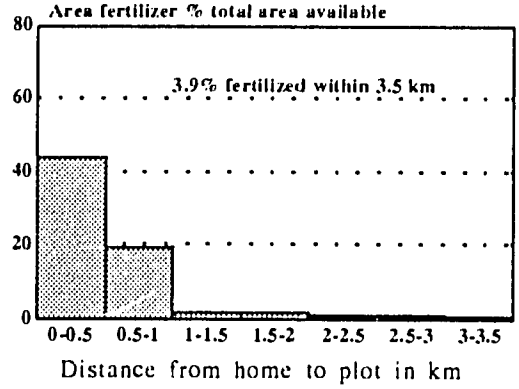
16. Farmers used a significant proportion of mineral fertilizers on cash crops and used organic manure on plots sown with food crops. Thus, 56% of mineral fertilizers and 93% of manure were applied to cereals and legumes. The corresponding figures for plots seeded with tiger nuts, the main cash crop, were 44% for mineral fertilizers and 7% for manure.

17. Manure was applied to a greater extent on legume-based crop associations (62%) than on cereals (31%); the latter were usually not sold except when there were significant surpluses. Thus, farmers appear to prefer monetary gains to the production of surplus food.

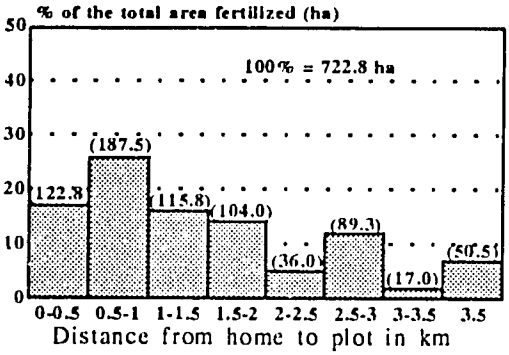
18. Research priorities highlighted by the study include development of modalities on the use of fertilizers (type, date, and dosage, adapted to the main cultural combinations).

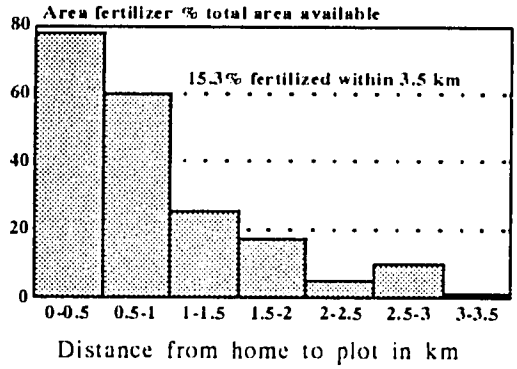
Farm manure, 1990



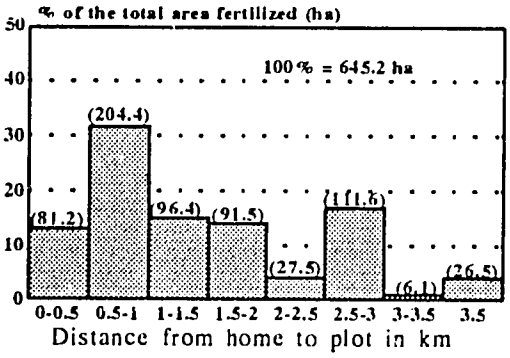


Mineral fertilizers, 1989





Mineral fertilizers, 1990



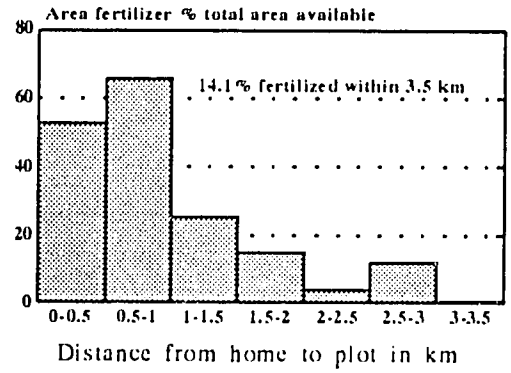


Figure 2. Fertilization and Distance (IFDC/SFRP, D. Pouzet, Tchizon-Kourégué, Maradi, Niger).

Discussion

Two issues pertaining to the design of SFRP socioeconomic research and the fertilizer revolving fund were discussed at length. Dr. Ogunbile sought clarification about the criteria used in selecting the research villages; he wondered whether there was any need for a control village in that the study was intended to be longitudinal.

Concerning the choice of research villages, Dr. Acheampong explained that a set of variables including accessibility, cropping systems, and farmers' willingness to participate in project activities was used to match the experimental and control villages. He explained further that because fertilizers were made available to almost all farmers in the experimental villages it was deemed necessary to include control villages in the study design to allow a comparison of users and nonusers of fertilizers by using pre- and post-test data from the experimental and control villages.

Regarding the fertilizer revolving fund, a question was raised as to whether it was appropriate to require farmers to pay back the cost of fertilizers since, in principle, SFRP is a research project. In reply, Dr. Rhodes explained that there are two aspects of the fertilizer issue which need to be understood. First, fertilizers for on-farm trials were made available to farmers free of charge. Second, it is important to note that there was a time lag between when the project was conceived (1985/86) and when actual field work began (1988/89). Within this relatively short period, very significant policy shifts with regard to fertilizer subsidies were made in several countries in the subregion including all three collaborating countries.

Consequently, the idea of fertilizing whole village farmlands at minimum or no cost to farmers, as originally conceived, had to be modified in the light of the prevailing policies. After exhaustive discussions with farmers, and consultations with national policymakers, a consensus was reached to the effect that farmers would pay part of proceeds from the sale of crops from their farms into a revolving fund to be managed by farmers. The objective was to create in each of the experimental villages a dependable source of funding for fertilizer use on a sustainable basis.

Dr. Rhodes explained further that, although some problems have occurred with the operation of the fund in Ghana and Togo, preliminary reports from Niger (reported elsewhere in this proceedings) indicate that the fund is serving the purpose for which it was intended.

Mr. Bitibaly observed that the idea behind the creation of the revolving fund was very useful, and he expressed the hope that the beneficiaries would honor their obligations. He cited, as an example, a similar project in his home country, Burkina Faso, that collapsed soon after donor funding ceased because no provision was made to ensure continuity.

Profitability of Fertilizer Use Options in Ghana

D. Pouzet, Agricultural Economist,
CIRAD/IFDC-Africa, Lomé, Togo

An analysis of profitability of fertilizers was carried out using results of trials with option packages conducted in 1989 on farms located at Adjamesu, the experimental village in Ghana. The trials were conducted on the principal cropping system of the study region, maize/cocoyam interplanted with cassava. The following fertilizer options were evaluated: F1: 80 N, 40 P_2O_5, and 40 K_2O in the form of urea and 15-15-15; F2: 80 N, 40 P_2O_5, and 40 K_2O in the form of urea, 50% partially acidulated phosphate rock (PAPR-50) from Togo, and KCl; F3: 80 N and 40 P_2O_5 in the form of urea and simple superphosphate; and F4: 45 N, 19 P_2O_5, and 19 K_2O in the form of ammonium sulfate and 15-15-15. F4 was the local extension recommendation. Options 1 to 3 were applied to 21, 20, and 19 farms, respectively. Each farm measured approximately 0.5 ha. In addition, each farm had a plot measuring 50 m^2 to which no fertilizers were applied.

The economic evaluation was performed using mainly the partial budget method. Costs associated with fertilizer use were compared with the value of the increases in production obtained as a result of the use of fertilizers. The analysis also included the average selling price at harvest and after a period of storage. The economic variables used in the analysis were gross benefits (GB), net benefits (NB), increase in revenue (IR), and value/cost ratio (VCR). GB represents the sum of the total value of production. NB is GB less production costs including the cost of fertilizers, transport, fertilizer application, and all other costs involved in the increase in production (harvest, transport, threshing, packaging, and storage). IR is the NB plus nonmonetary costs (labor). The VCR is the ratio between the GB and monetary costs (price of fertilizer and monetary cost involved in storage).

The costs and prices were estimated on the basis of data collected through a series of surveys [8].

The following are results of the direct effects of fertilizer application to maize in the village economic environment during the 1989/90 crop year:

1. The price of maize fluctuated so much that farmers could not envisage their income at the beginning of the farming season (Figure 3). For example, the maize price at the beginning of harvest (20 cedis/kg) increased elevenfold to peak at about 220 cedis/kg.

2. Regardless of the type of option, the monetary cost of production including storage represented 65% of total costs; fertilizers alone accounted for 53% of the costs.

3. Storage costs, including labor (4%) and other monetary costs (15%), accounted for 19% of the total cost of production. However, these figures do not include an estimated 10% loss in grain weight during storage (10% of GB).

Sale at Harvest

1. The farmer earned an average of 30 cedis/kg of maize.

2. Only F4 yielded a satisfactory average VCR of 2.6. Results of the other options indicate a VCR of less than 2, an indication that it could be very risky for the farmer to invest in this option.

3. An analysis of the VCR distribution (Figure 4) shows that 57% of farmers who used F4 attained or were slightly above the minimum risk limit (VCR = 2). Thus, about 43% of farmers achieved results that may be considered as satisfactory at the village level.

Note

8. See "Agroeconomic Studies of the SFRP: Methodology" (in this volume).

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4. On the average, F4 yielded relatively low profits (NB=15,000 cedis/ha). However, assuming that labor is provided free of charge by family members, the IR of 27,000 cedis/ha may be considered as quite high.

5. F4 required a total of 25.5 workdays, which amounts to about 12,000 cedis/ha.

Sale After Storage

1. It is imperative that maize be stored for about 7.5 months in order to sell for an average price of 67 cedis/kg.

2. With the exception of F2 (PAPR-50), all the options yielded a VCR of 2.5 or better; F4 turned out to be the best option (VCR > 3).

3. Even though the monetary cost of F4 (36,000 cedis/ha) is higher and involved greater risk than F3 (23,100 cedis/ha), F4 resulted in a much higher VCR (3.4), NB (56,000 cedis/ha), and IR (72,700 cedis/ha) than did F3. The corresponding figures for F3 were 2.9; 48,000 cedis/ha; and 62,300 cedis/ha.

4. The VCR distribution shows that 80% of farmers who used F4 attained a VCR of no less than 2. This is quite acceptable at the village level.

5. Eighty percent of farmers using F3 earned at least 35,000 cedis/ha, whereas farmers who used F4 earned only 15,000 cedis/ha. These results confirm the need to seek solutions to farmers' financial problems that will enable them to adopt the relatively more expensive but profitable options (F3 instead of F4).

Conclusion

1. F4 appears to be the most profitable option regardless of the time of year crops are sold. It can therefore be recommended.

2. F3 can be recommended only to farmers who are capable of making an additional investment of 58.4%/ha and can wait about 7.5 months before they sell their produce. In this way they may increase their revenue by 18.5% and save 14.5% of cropland.

3. The creation of an efficient credit scheme may enhance the adoption of the relatively more expensive option, which appears to be more profitable than the extension recommendation.

4. Estimates of the residual effects of the fertilizers on crop rotation, as well as on cocoyam and cassava, will greatly enhance the results.

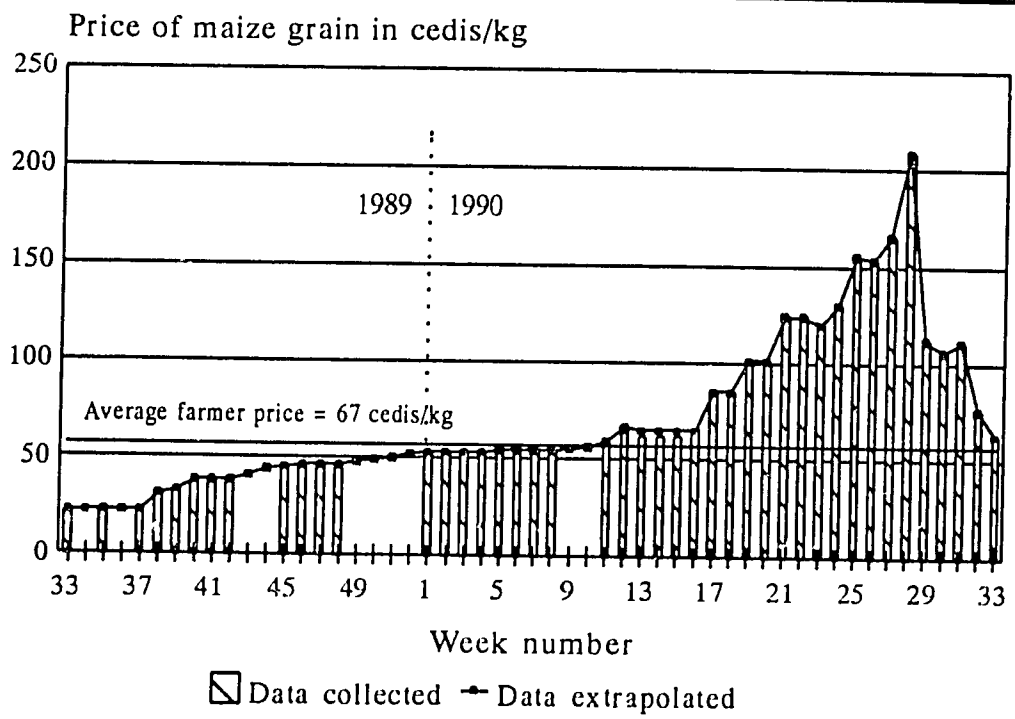

Figure 3. Maize Grain Price in Adjamesu Market (Ghana).

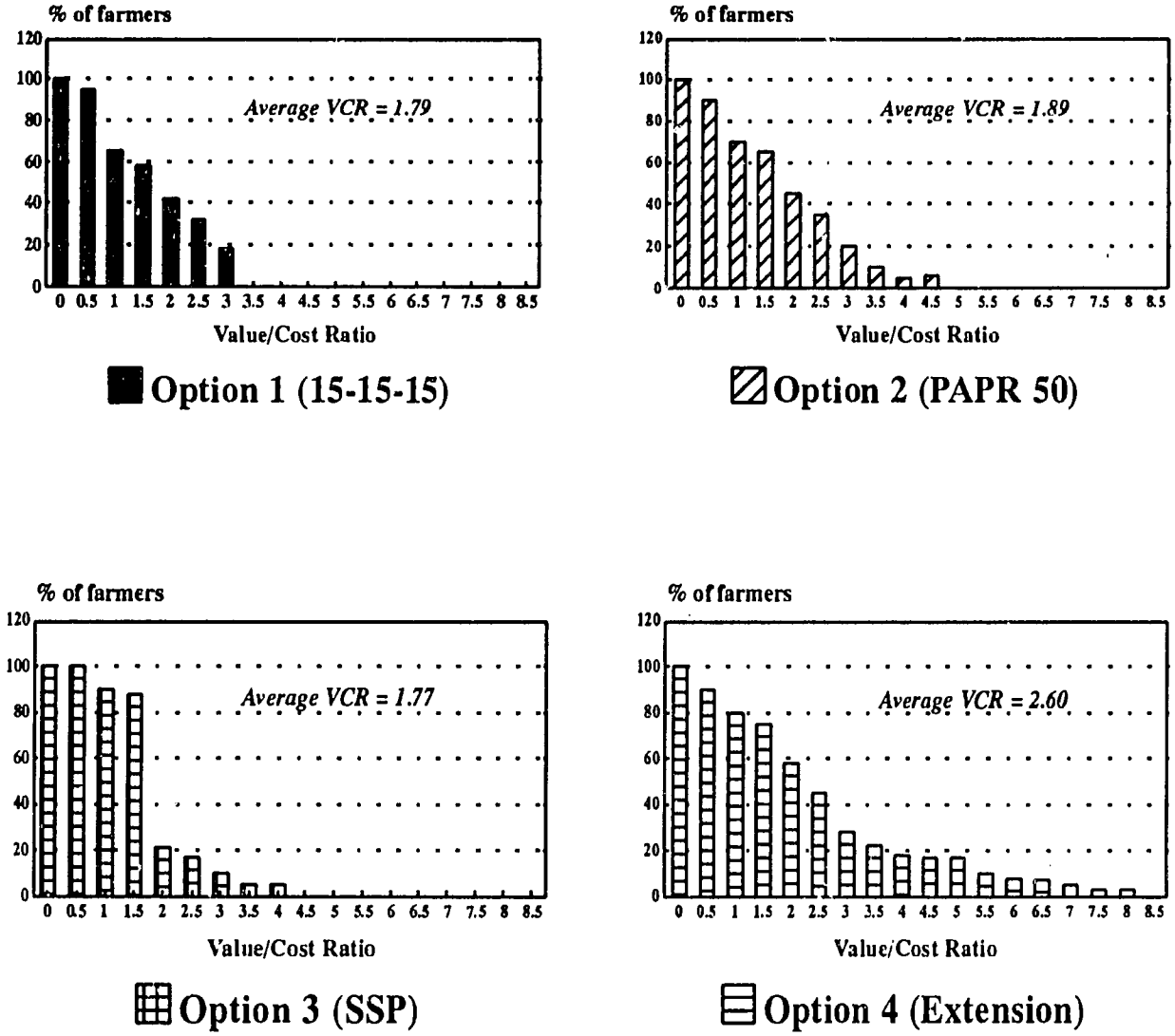

Figure 4. VCR Distribution at Harvest in Adjamesu (Ghana).

Direct and Indirect Benefits of Fertilizer Use

C. A. Baanante, Economist, Resources Management Research and Development Division, IFDC, Muscle Shoals, Alabama, U.S.A.

Estimates of maize production function models and labor use functions obtained using cross-sectional farm survey data from the village of Adjamesu were used to calculate the direct and indirect benefits of fertilizer use in maize production. A summary of these results is presented here.

Direct Benefits

1. The gross benefit of fertilizer use is equal to 558 kg of maize/ha.

2. The direct benefit and profitability of fertilizer use on maize were calculated at three price levels, namely, 50, 65, and 80 cedis/kg. At 65 cedis/kg, all fertilizer options tested are profitable. Added profits (increased returns to land) vary from 6,534 cedis/ha (US $24.70) for the option of 15:15:15 + urea to 8,862 cedis/ha (US $33.60) for the option of PAPR-50 + urea + KCl. At 850 cedis/kg, the incentive for farmers to use fertilizer is eliminated. Compared to 65 cedis/kg, at 80 cedis/kg for maize, the net benefits and added profits of fertilizer use increase by about 100%.

Indirect Benefits

1. In terms of employment and income of farm labor, the average product of farm labor is 6.7 kg of maize per workday. Thus, the value of the average product of labor at the price of 65 cedis/kg of maize is 436 cedis/workday.

2. If the opportunity cost (return) of farm labor is assumed to be 50% of the value of the average product, the net economic benefit from the employment of farm labor generated by fertilizer use would be 8,066 cedis or US $28.80 per hectare.

3. In terms of benefits to consumers, the benefits result from the increase in maize production attributable to fertilizer and the decline in the price of maize. The estimated consumer surplus is equal to 6,278 cedis or US $22.40 per hectare of maize.

4. Benefits of fertilizer use to the environment were obtained by comparing, on a long-term basis (30 years), two possible but opposite scenarios; one scenario assumes the continuity of traditional practices of shifting cultivation (scenario 1), and the other the rapid adoption and use of fertilizers (scenario 2). Flows and present value of gross and net benefits that are foregone due to the shortening of the fallow, decline in soil fertility, and lack of fertilizer use are calculated using constant 1989 maize and fertilizer prices.

Production function estimates are used to calculate predicted maize yields, and an annual discount rate of 20% is used to calculate the present value of net benefits. The present value of the net benefit of fertilizer use, through its impact on yields and the conservation of the soil resource base (soil fertility) over the 30-year period, amounts to 37,158,520 cedis (US $132,709) for 12,000 ha of total land area or 1,000 ha of area cultivated.

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Farm-Level Constraints to Fertilizer Use

K. Acheampong, Rural Sociologist, IFDC-Africa, Lomé, Togo, and T. P. Thompson, Sociologist, Resources Management Research and Development Division, IFDC, Muscle Shoals, Alabama, U.S.A.

The importance of fertilizers in accelerating food production in sub-Saharan Africa is well recognized by agricultural researchers and policymakers. Dr. Norman Borlaug, a Nobel laureate, has been quoted as saying that "if high yielding varieties are the catalyst, fertilizer is the fuel of the green revolution." Current estimates indicate that 60% of the food production needed in sub-Saharan Africa by the turn of this century must come from increased yield.

Despite the recognized value of improved seeds and fertilizer for agricultural productivity, fertilizers are hardly used by most small-scale farmers in West Africa. Less than 10 kg of fertilizer nutrients is used in West Africa per hectare of arable land compared to 91 kg/ha in Asia, 92 kg/ha in the United States, and 231 kg/ha in Western Europe. This paper summarizes farm-level constraints to fertilizer use as reported by farmers in three contrasting agroclimatic regions in West Africa.

Data and Methods

Data for the study are from the baseline socioeconomic farm survey of farmers from the SFRP research villages in the humid region of Ghana, the Savanna region of Togo, and the Sahelian region of Niger. Data from the surveys included past use of fertilizers, type(s) and quantity of fertilizer used during the survey year, and the perceptions of farmers about constraints to fertilizer use.

The calculations of scores and ranks for the perceived constraints are based on two assumptions. First, it is assumed that the relative importance of the first constraint mentioned is equal to three times the third most important constraint mentioned. Thus, a constraint that is mentioned three times in the third order of importance is as important as a constraint mentioned once in the first order of importance.

Second, it is assumed that the importance of the second constraint is equal to one and one-half (1.5) times the importance of the third most important constraint mentioned by respondents. Thus, a constraint that is mentioned two times in the second order of importance is as important as a constraint mentioned once in the first order of importance.

These two assumptions provide a basis for calculating scores for relative importance (SRI) of constraints to fertilizer use as follows:

$$SRI^3 = \sum_{j=1}^{3} W_j f_j$$

where:

W_j = weights.

f_j = frequencies for a given i constraint and j orders or ranking.

Findings

The scores and ranks for perceived constraints to fertilizer use by region are provided in Table 1. It is clear from the data that, regardless of region, lack of money or credit programs to buy fertilizers is the most important constraint to fertilizer use as reported by farmers. This justifies the creation of fertilizer revolving funds by the SFRP in the pilot villages as a dependable source of funding for fertilizer use on a sustainable basis.

Farmers in Ghana cited inadequate knowledge about the types, correct doses, and combinations of fertilizer that could provide maximum yields at minimum cost as the second most important constraint to fertilizer use. In contrast, unavailability of fertilizers when needed and inadequate rainfall were ranked as the second most

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Table 1. Ranked Scores of the Relative Importance of Constraints to Fertilizer Use as Reported by Farmers by Region

Constraint	Region					
	Ghana		Togo		Niger	
	Score	Rank	Score	Rank	Score	Rank
Lack of money or credit	118.5	1	107.7	1	96.5	1
Fertilizer not available	35.5	5	68.0	2	10.3	4
Distance to dealer	-	-	41.0	3	-	-
Inadequate rainfall	-	-	34.0	4	29.2	2
Inadequate knowledge	82.5	2	20.5	5	13.3	3
High prices	45.0	4	16.2	7	1.7	5
Excessive weed growth	55.0	3	-	-	1.5	6
Damaged crops[a]	34.5	6	-	-	-	-
Other[b]	30.5	7	18.0	6	-	-

a. Includes changing the taste of food and rotting of cassava.
b. Includes lack of labor, insecure land tenure, lack of seeds, small size of plots, and difficulty in fertilizer application.

important constraint to fertilizer use by farmers in Togo and Niger, respectively. By unavailability of fertilizer, farmers in Togo implied the restriction imposed by SOTOCO, the local cotton marketing agency, to use fertilizers only for the cultivation of cotton.

The third most important constraint cited by farmers in Ghana is excessive weed growth that accompanies fertilizer use. This constraint is not very important to farmers in Niger, and in Togo it was not mentioned at all. One may attribute this constraint to the inadequate knowledge of the Ghanaian sample about fertilizer use, in particular the type, timing, and recommended methods of fertilizer application.

Farmers in Togo ranked distance to a fertilizer dealer as the third most important constraint to fertilizer use. This constraint is not cited by farmers in Ghana and Niger and may be explained by the dispersed pattern of settlements in the pilot region of Togo.

It is important to note that by outposting agricultural extension officers in the pilot villages and by making fertilizers available to farmers at the farmgate through the fertilizer revolving funds, the SFRP clearly addresses three of the four most important constraints to fertilizer use as reported by farmers in the three regions.

These findings were useful in developing extension training programs for collaborating national staff and farmers. Data from subsequent surveys will be used to describe and assess changes in farmers' perceptions about fertilizer use following extensive use of fertilizer in the pilot villages.

Labor Contributions of Women to Crop Production Activities in Three Regions of West Africa: An Analysis of Farm Survey Data

T. P. Thompson, Sociologist, Resources Management Research and Development Division, IFDC, Muscle Shoals, Alabama, U.S.A., and K. Acheampong, Rural Sociologist, IFDC-Africa, Lomé, Togo

The literature on "Women in Development" suggests that regardless of country, region, cultural group, climate, or types of crops grown, women in sub-Saharan Africa always and everywhere are the dominant source of labor. Although some studies have questioned the validity of this appraisal [9], a sort of conformity to the generalization about the dominant role of women in crop production activities in sub-Saharan Africa continues to be cited in the literature [10].

This paper uses data from the baseline farm-survey of the SFRP in Ghana, Togo, and Niger to (1) describe and test hypotheses about labor contributions of women for the crop production activities of land preparation, planting, weeding, pest control, fertilizer application, harvesting, and marketing, and (2) discuss the implications of the results for the design and implementation of policies to enhance the role of women in agricultural production and economic development in the study regions.

Data Collection

Based on information provided by local extension workers and an exploratory survey of 26 villages, a purposive sample of six villages was selected for intensive survey work. To facilitate comparisons, two villages in each country were chosen, and a random sample of 60-70 farmers stratified by gender was selected from each village for interviewing. This yielded a total sample of 375 farmers, including 133 women.

Between August and December 1988, data were collected in all the six villages through a face-to-face interview and a questionnaire that contained open- and closed-end items. The questionnaire was designed to generate data on households and plots.

Data generated at the household level included cultural group affiliation; household composition, location, education, and employment; land availability and tenure; sources of information about fertilizers; disposal and use of crop production; and perceptions of farmers about constraints to fertilizer use and agricultural production. At the farmplot level, farmers were asked to indicate the number of plots they cropped during the survey year; for each plot mentioned, they were asked to indicate the gender of the manager, tenure status, area, length of fallow, and the number of workdays of family and hired labor used for each of the seven major crop production activities. Thus, the labor use analyses are based on a total of 984 plots comprising 827 ha that were cropped during the survey year.

Notes

9. Eicher, C. K., and D. C. Baker. 1982. "Research on Agricultural Development in sub-Saharan Africa: A Critical Survey," MSU International Development Paper No. 1, East Lansing, Michigan: Department of Agricultural Economics, Michigan State University.

10. Saito, Katrine. 1991. "Extending Help to Women in LDCS: What Works and Why," *Finance and Development* (September) 29-31.

Data Analyses

Because of the multi-stage stratified random design, the data are weighted to reflect the distribution of the sample populations in the study regions. Two days of labor of a child (<13 years old) are assumed to be equal to one labor day of an adult. A t-test was conducted to test various hypotheses in determining (1) the significance of the contributions of labor from men, women, and children, (2) the presence and degree of gender specialization, (3) the influence of the gender of the plot manager on the degree of gender specialization in performing various crop production tasks, and (4) the influence of the manager on the relative contribution of hired labor in performing specific tasks. Statistical analysis involving the use of Duncan's multiple range test was conducted to compare means of (1) the degree of gender specialization in performing various tasks, (2) contributions of women to various activities, and (3) the contribution of hired labor to various activities by country and gender of the plot manager.

Findings and Implications for Policy

The data do not support the generalization that agricultural work south of the Sahara is dominated by women or that the region is one of "female farming par excellence." Therefore, a naturalistic view of a division of agricultural labor based solely on gender appears fallacious. Labor contributions vary by activity, region, and gender of plot manager. Men appear to contribute more labor than women in all activities except planting and harvesting. Land preparation, weeding, pest control, and fertilizer application represent significant task specialization of men regardless of region. The exception here is Niger, where the participation of women in land preparation is significant. Therefore, resources for technology and training that involve tools, timing, and methods would be most efficiently used for bolstering the skill of men in the three countries.

Finally, the data indicate that women are actively engaged in agriculture and should be given more attention by policymakers and extension workers. Planting and harvesting work, for example, are overwhelmingly specialized tasks of women. Therefore, technology and training involving seeds, methods of planting, timing, and plant density (planting work) and threshing, processing, and storage (harvesting work) would clearly be most beneficially directed toward women. In this regard, training of additional women extension workers to work with women farmers would be most beneficial.

Farming Practices and Economic Profitability of Inputs on Cotton in Burkina Faso: The Research Approach

G. Faure, Agricultural Economist, Institut de Recherches du Coton et des Fibres Textiles (IRCT)/CIRAD, Bobo Dioulasso, Burkina Faso

The objective of the farm surveys initiated in Burkina Faso and Cameroon was to improve the knowledge of cotton companies on the use and efficiency of inputs granted to farmers for cotton production. In future, this study will be extended to other Francophone countries where cotton is produced.

After a preliminary survey and collection of some statistical data, the cotton-producing area was divided into three homogeneous zones; one village per homogeneous zone (total of 3 villages) was selected. This was followed by a diagnostic study of the fertilizer management problems at the village level from a historical perspective. Some units of production were selected through a typology of farms based on the degree of mechanization. These units of production were all different, but they were characteristic of each homogeneous group. A series of surveys including but not limited to monitoring of all the fields and assessment of receipts and expenditures helped us to gain deeper insights into the farming system.

In order to describe the farming practices in cotton production, a detailed monitoring of some technical packages for crop production was undertaken. In each village, 150 plots located in the cotton farms were split into two groups: one represented the farmers' practice and the other, the local extension recommendation. A typology of these packages was established by measuring the efficiency of each practice. In-depth interviews were conducted with selected cotton growers in an effort to understand farmers' priorities and identify the farming strategies.

A Comment

S. T. Fall, Coordinator, Food Resources Program, Institut Senegalais de Recherches Agricoles (ISRA) Dakar, Senegal

It is well recognized that soils in the Sudano-Sahelian zone of West Africa are deficient in organic matter and plant nutrients, especially phosphorus. Consequently, land degradation is a serious problem in the subregion. This phenomenon is widespread in rangelands where over-exploitation, in the form of overgrazing, the pounding hooves of hungry animals, and destruction of vegetation by pests such as locusts, exposes the soil and leads to wind erosion.

Evidence of rangeland degradation includes less nutritive pasture and the proliferation of weed species such as *Calotropis procera* or *Zomia glochidiata*. This has indirectly resulted in insufficient supply of animal protein, in particular meat and milk, and a decrease in revenue for rural dwellers who engage in stock raising.

Because pasture is the principal source of food for ruminants in the Sudano-Sahelian zone, the attainment of food self-sufficiency, in particular animal protein, will depend upon the productivity of existing rangelands. In this regard, the possibility of using organic and inorganic fertilizers on rangelands needs to be investigated and probably encouraged. Such a study will require a multi-disciplinary team including agronomists, animal scientists, and socioeconomists.

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Discussion

Dr. Ogunbile opened the discussion with two successive questions for Mr. Pouzet regarding the presentation, "Profitability of Fertilizer Use Options in Ghana." First, he wanted to know why the minimum value-cost ratio was set at 2. Second, he wondered whether the cost of storage was considered in the benefit/cost analysis. Mr. Pouzet explained that his analysis was guided by previous research in the subregion and that 2 is the normative value often used by FAO and other agricultural workers for economic analysis of most crops in sub-Saharan Africa. To the second question, Mr. Pouzet indicated that he did not include storage costs in the analysis, but he was confident that, assuming 10% storage loss, the profit margin could still be higher than if farmers had sold grain immediately after harvest. He indicated, however, that he would include that variable in the final write-up of his presentation.To another question from Dr. Thompson concerning the average percentage of a maize crop that farmers sold during the survey year, Mr. Pouzet answered that he did not include that variable in the study and that he will include it in a subsequent study. Mr. Faure pointed out that improved crop husbandry practices can have significant effects on the profitability of fertilizer use, but that aspect was not covered in detail in the analysis. Mr. Pouzet argued that he addressed some aspects of the influence of improved cultural practices in his presentation although the specifics were not very apparent because of the method of analysis used.

Dr. Kelly commended Dr. Baanante for the innovative approach used for the study, "Direct and Indirect Benefits of Fertilizer Use." However, she expressed the view that time series rather than cross-sectional data would be more appropriate for the type of model presented. Dr. Baanante explained that his presentation should be seen only as the first step towards model development and that he recognizes the need for additional data to validate the model. On his part, Dr. Ogunbile suggested that Dr. Baanante should consider including agroclimatic data in subsequent analyses to enhance the predictive power of the proposed model. To a question by Mrs. Badiane as to whether soil fertility levels were incorporated in the model, Dr. Baanante replied that some aspects of it are implicit in the model.

Discussions of the presentation "Labor Contributions of Women . . ." centered on two related issues, namely, the spatial context and generalization of the study findings. While commending the authors for an in-depth analysis of the subject, Mrs. Fall emphasized that the study would gain a much wider acceptance if it involved women from a greater number of ethnic groups/countries in the subregion especially in those areas where very little is known about activities of women. This view was shared by Mr. Akle who noted that even in his home country, Benin, labor contributions of women to agricultural work vary significantly across agroecological zones. Dr. Riedacker commended the effort put into the presentation; he suggested, however, that conclusions from the study can be examined in a wider perspective by putting it in a global context on the basis of previous scientific evidence on the subject. Dr. Thompson agreed with the comment made by Dr. Riedacker; however, he explained that a significant proportion of research work on the subject has been done by people he referred to as "activists."

Part IV: Achievements, Problems, and Future Directions of the SFRP

Achievements and Problems in the Implementation of the SFRP

Achievements and Problems in the Implementation of the SFRP in Ghana

Achievements and Problems in the Implementation of the SFRP in Togo

Achievements and Problems in the Implementation of the SFRP in Niger

Discussion

Sustainable Nutrient Management/Soil Conservation Systems Within Watersheds: A Project Proposal

Discussion

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Achievements and Problems in the Implementation of the SFRP

E. Rhodes, Agronomist (SFRP Team Leader),
IFDC-Africa, Lomé, Togo

Implementing an on-farm research and development project at the village level in contrasting ecologies in three countries is very challenging and also rewarding. Under the best of circumstances, 7-10 years usually elapse between the time that the research and development effort is first funded and the point when the benefits of these investments begin to show up in national agricultural systems and in farmers' fields and their homes. It is in this context that the summary of achievements and problems presented here should be examined.

Achievements

1. IFDC's collaboration with national research and extension workers through joint workplan meetings, training programs, monitoring and evaluation of project activities including soil/plant analyses, production of maps, and data processing has enhanced and strengthened the linkages between the three institutions.

2. Farmers and extension workers actively participated in the testing and evaluation of fertilizer/manure option packages and on-farm research trials; thus, the frequency of contact and interaction among farmers, extension workers, and researchers increased considerably.

3. Research and extension workers have received training in the techniques of fertilizer use, collection of agronomic and socioeconomic research data, and extension communication skills.

4. Fertilizer revolving funds have been established in three countries. The funds have indirectly empowered the beneficiary communities to initiate development projects such as village market and access road construction projects in Tchizon (Niger) and rehabilitation of a community granary, which is also used as a fertilizer depot in Naki-Est (Togo).

5. Crop yields and food production doubled in the experimental villages in years when rainfall was adequate.

6. As a result of fertilizer use, tomatoes have become increasingly important as a cash crop in the experimental villages of Ghana. Likewise, fertilizer use has increased the importance of maize as a cash crop in the experimental villages of Togo and that of tiger nuts *(Cyperus esculentus)* in the villages of Niger.

7. Reports have been prepared, and more are to follow on the technical feasibility, economic viability, and social acceptability of soil fertility restoration strategies. These reports would have policy implications for agricultural development in West Africa.

8. A mailing list for SFRP reports and papers has been compiled from participants of this workshop.

Problems

1. Delays in the appointments of in-country coordinators led to the late start-up of field activities in 1988.

2. High turnover of national staff resulting from the death of a national coordinator, reorganization of entire ministries, promotions, transfers, and resignations required the allocation of time and resources to train replacements and in some cases recruit new staff.

3. Misunderstandings with farmers in Ghana and Togo as to whether the fertilizers supplied in 1988 for the evaluation of option packages were *gratis* adversely affected reimbursement into the fertilizer revolving funds.

4. Political unrest in 1990/91 in Togo and in Niger affected the level of participation of IFDC staff in some training sessions and other field programs.

5. Inadequate rainfall in the pilot areas of Togo and Ghana in 1990 seriously affected crop production and data collection.

6. The heavy workload did not allow the implementation of SFRP in irrigated areas as originally intended.

7. As indicated earlier, the relatively short duration of the project precludes an in-depth assessment of the medium- and long-term impacts of SFRP interventions in the pilot areas.

Achievements and Problems in the Implementation of the SFRP in Ghana

Samuel Opoku, Regional Crops Services Officer (SFRP In-County Coordinator), Ministry of Agriculture, Kumasi, Ghana

The main thrust of SFRP activities in Ghana has been in the experimental and control villages of Adjamesu and Hwidiem, respectively. In addition, selected farmers from the villages of Boamang and Anyinasuso are actively involved in the on-going farmer/researcher-managed on-farm trials. Following is an outline of the project's achievements and constraints and suggestions for the future.

Achievements

1. Following extensive use of fertilizers and improved seeds in 1989 in the experimental village, grain and tuber yields increased sharply above baseline levels.

2. Productivities of land and labor have increased considerably in the experimental village because farmers are increasingly cultivating maize in the major and minor seasons. This has been made possible by the availability of fertilizers through the fertilizer revolving fund.

3. In the experimental village, tomato production using fertilizers from the revolving fund has emerged as one of the most important income- and employment-generating activities for farmers and those young people who leave school.

4. Through regular field days, farm visits, and small group discussions, farmers in the target villages are increasingly adopting improved seeds and fertilizers. This is particularly so for urea, which hitherto was unknown to farmers and therefore not used in the villages.

5. The technical expertise, confidence, and communication skills of the extension staff have improved considerably through their participation in the training programs organized by IFDC scientists.

6. Farmers in the Ashanti region are increasingly adopting prototypes of improved cribs built in the experimental village to store maize.

7. Perhaps one of the greatest achievements of SFRP in the Ashanti region can be seen in the selection of a collaborating farmer from the experimental village as the best National Small-Scale Maize Farmer for the year 1989. The farmer received a corn mill as a prize from the Government, and he has since installed it in the village to serve the needs of the local people.

Problems

1. The bumper harvest of 1989 was experienced in almost all the 10 regions of Ghana, in particular those regions where Global 2000 and IFAD are implementing similar agricultural development projects. Consequently, grain prices in several regions of the country tumbled by as much as 50% of 1988 prices. Farmers who decided to hold stocks in anticipation of better prices incurred severe losses due to inadequate storage facilities. In effect, farmers in the experimental village, like their counterparts elsewhere in the country, became victims of their own success.

2. Farmers' confidence was again badly shaken in 1990 due to a long dry spell midway in the cropping season. Crops failed, and several farmers fell back in the payment of the cost of fertilizers they received under the fertilizer revolving fund. Consequently, fewer farmers used fertilizers during the 1991 crop year.

3. The project lost two middle-level staff (an agronomist and a socioeconomist) in 1990. The former was transferred to headquarters, and the latter left

the country for further studies abroad. However, two junior staff members were upgraded to fill their positions after undergoing intensive training provided by IFDC scientists.

4. As indicated earlier, some farmers are behind schedule in the repayment of loans granted under the fertilizer revolving fund, partly because of overproduction (1989) and bad weather (1990). Nevertheless, there are some farmers who continue to harbor the notion that SFRP, being a research project, should provide fertilizers *gratis*. Such attitudes are greatly hampering the operation of the fund.

Despite these problems, the majority of farmers are enthusiastic and look forward into the future with great optimism. As one farmer put it:

> The weather failed us in 1990 so we were very cautious about how much to invest in our farms during the 1991 crop year. Come 1992 we are going to repeat the miracle of 1989, store our produce in our beautiful cribs, and sell later to honor our debt obligations to the revolving fund.

Future Directions

With the complete withdrawal of government subsidies on fertilizers, farmers are likely to face many challenges with regard to how much of their limited resources should be committed to the purchase of fertilizers.

It will therefore be useful to consider moving from the forest zone to the transitional or Guinea Savanna zone where the following "favorable" conditions for fertilizer adoption prevail:

- Soil degradation is relatively more widespread than in the forest zone.
- Population pressure on land is relatively high.
- Land fallow is virtually nonexistent.
- The cropping system includes cash crops such as tobacco, cotton, and cowpeas that have a ready market.
- Maize is a major component in the local diet.

These factors should feature prominently in the discussions on the followup project.

Achievements and Problems in the Implementation of the SFRP in Togo

K. Abalo, Agronomist (SFRP In-Country Coordinator), Institut National des Sols, Dapaong, Togo

Objectives of the Project

Field activities of the SFRP began in the Savanna region of Togo in 1988. The project's long-term objectives are to boost food production, increase the income of farmers, and promote agriculture and rural development by restoring the fertility of land under cultivation.

The specific objective is to study the agricultural, socioeconomic, and environmental viability of using fertilizers and soil amendments as an investment strategy to restore and maintain soil fertility in West Africa. A very important component of the project is the training of national collaborators in the fields of research and extension.

Achievements

The project can be credited with several achievements during the past 3 years.

1. The project has successfully demonstrated to many farmers the importance of fertilizers in enhancing soil fertility and crop yields, including monetary gains they can derive from fertilizer use. Farmers in the experimental village of Naki-Est are increasingly interested in using fertilizers on food crops and not only on cotton alone as they did in the past. Consequently, crop production is increasingly being intensified.

2. The project has helped to promote cultivation of maize as a "new" cash crop. Increased use of fertilizers has resulted in a sharp increase in the production of maize in the experimental village. In the past, limited maize was produced in the village due to low soil fertility. But with the use of fertilizers, maize has turned out to be the third most important cash crop after cotton and groundnut.

3. Another achievement of the project is the general increase in the level of crop production in the experimental village thereby contributing immensely to the relative attainment of food self-sufficiency in the village.

4. Field surveys have shown significant improvements in the socioeconomic well-being of farmers in the experimental village as indicated by an increase in (a) the number of houses with corrugated iron roofs, (b) acquisition of bicycles and other capital items, and (c) frequency in the performance of traditional ceremonies including weddings and funerals—the two most important social events in Moba/Gourma communities.

5. The project has helped to establish data banks on crops and farming systems as well as the use of family and hired labor. Fertilizer use among the general farm population has increased considerably.

6. Training is another important achievement of the project. Research assistants and extension workers assigned to various aspects of the project are now quite conversant with the collection of agricultural and socioeconomic data. Farmers have acquired skills in the storage and application of fertilizers, post-harvest crop management, and striga control techniques. Farmers have also been trained in the management of the fertilizer bank established under the fertilizer revolving fund.

Constraints

1. Farmers in the experimental village complain of a drop in the selling price of food crops in the village market due to the large surpluses obtained as a result of fertilizer use. For example, during the latter part of 1989 and in early 1990 the price

of a 3-kg bowl of millet or sorghum sold at FCFA 175 in the control village (no fertilizer was used); the same quantity of grain sold for about FCFA 125 at the village market in Naki-Est, the experimental village.

2. The rate of recovery of loans granted to farmers under the fertilizer revolving fund has been lower than expected. The main reason cited by farmers is a long dry spell midway in the 1990 cropping season resulting in poor yields. But the fact still remains that, as first-time users of credit facilities to produce food crops, several of the farmers did not manage the incomes they earned from the good harvest recorded in the previous year.

3. Other constraints include the limited size of plots, which hampers intensified use of fertilizers, shortage of labor, lack of improved seeds, and ethnic diversity, which has sometimes been a source of misunderstanding and friction within the farmer association.

Suggestions

In view of difficulties in dealing with large groups, we wish to propose that the existing farmer association be reorganized into smaller groups to ensure a more effective monitoring of the groups' activities.

- Considering the problems posed by flooding in lowland areas and soil erosion on slopes, it has become imperative to consider including soil and water conservation in the project's activities.

- Training of farmers should continue, with emphasis on soil conservation techniques, selection and use of improved seeds, fertilizer application, crop storage/disposal, and proper management of farm incomes.

- Now that the project has been implemented for about 3 years, it has become necessary to examine ways of enabling farmers in the control village to have access to the fertilizer bank.

- The success of the first phase of the project, as reflected in the general satisfaction of farmers in the experimental village, inspires us to call for project continuation and, if possible, replication in other regions of Togo where similar problems of soil fertility and declining food production have been reported.

Achievements and Problems in the Implementation of the SFRP in Niger

A. Ndiaye, Entomologist (SFRP In-Country Coordinator), Institut National des Recherches Agronomiques du Niger (INRAN), Maradi, Niger, and M. A. Zarafi, Agricultural Economist, INRAN, Maradi, Niger

Objectives of the Project

Apart from very limited irrigated areas, the bulk of food consumed in Niger is produced by small-scale farmers under rainfed conditions. Modern farming inputs, especially mineral fertilizers, are used on a very limited scale. Consequently, crop yields are very low, and the Government has to import significant amounts of grain to counter perennial food shortages.

In line with the Government's policy of food self-sufficiency, INRAN, the national agricultural research institute, readily accepted IFDC's invitation to collaborate in the implementation of the Soil Fertility Restoration Project. The general objective of the project is to boost food production, increase farmers' incomes, and promote agricultural and rural development in Niger.

The project specifically aims at:

- Examining the agricultural and socioeconomic viability of using fertilizers and soil amendments as complements of investment strategies for restoring the productivity of impoverished soils in selected areas of West Africa.
- Training counterpart staff in the areas of plant nutrient technology development and transfer.
- Developing the use of local resources as soil-enriching agents.
- Establishing a revolving fund through which inputs and other credit facilities are made available to farmers on a sustainable basis.

Constraints

As indicated earlier, crop production in Niger is characterized by the arid climatic conditions of the Sudano-Sahelian zone. Low rainfall and impoverished soils are quite often the limiting factors for crop production.

Profitability of fertilizer use depends largely on adequacy of rainfall, which in the Nigerien situation is very variable and unpredictable. Therefore fertilizer recommendations to farmers in this environment should always take into account the risk of water deficit.

Soil fertility and cultural practices also affect crop response to fertilizers. Other constraints include long distances to farms and input distribution centers and inadequate pricing policies for the cereal production subsector.

Activities Undertaken

In pursuance of project objectives, we undertook several activities including the following:

- Agricultural and socioeconomic surveys in two villages in the Madarounfa District of Maradi from 1988 to 1991.
- Establishment of on-farm trials involving different fertilizer/farmyard manure investment packages in the experimental village of Tchizon and three other villages from 1988 to 1991.
- Creation of a farmer-managed fertilizer revolving fund.

Impact of the Project in the Experimental Village

In this discussion, we will examine only tangible or visible outcomes of our approach pending a more detailed analysis of the research data. A comparison of the past and current status of agricultural production shows a marked increase in crop output and incomes in the experimental village according to the following indicators:

1. Increase in the number of cribs/storage bins in the village.

2. Construction of new houses and renovation of old ones using modern building materials, especially cement.

3. Construction of a market in the village in 1990.

4. Increase in the number of pilgrims to Mecca since 1989.

5. Increase in the number of livestock.

6. Construction of a 3-km access road from Tchizon to the main highway through communal labor and with assistance from a fertilizer dealer and the local government authorities.

In social terms, the creation of the fertilizer bank has enabled the management committee to acquire tremendous experience in the running of the village cooperative. The very existence of this fertilizer bank is beneficial to the village; we would therefore expect its adoption by other village communities. Table 2 shows quantities of fertilizer purchased and loaned to farmers and the amount of money recovered during the period 1989 to 1991.

Farmers' Viewpoint

Since the initiation of the project in 1988, regular contacts have been established through periodic meetings with INRAN and the IFDC research team, farmers, and extension officers.

Opinions expressed by the various parties involved in the project indicate that the creation of the fertilizer revolving fund/bank is highly appreciated. However, the modest successes recorded so far have not been without problems; these problems need to be addressed.

1. **Problem of fertilizer storage**

   The cooperative needs a warehouse for the storage of fertilizers purchased in bulk each year; such a warehouse can also replace traditional cribs in which to store grain for use during the lean season.

2. **Problem of procurement of modern farming implements**

   The cooperative expressed the wish to broaden the scope of its lending operations to include modern farm equipment and tools. This would require support in the form of additional capital so that farmers who wish to mechanize some aspects of their farm work can borrow money to acquire the necessary tools and equipment.

3. **Problems relating to the production of tiger nuts**

   The main cash crop of farmers in Tchizon is tiger nuts. Proceeds from the sale of this crop enable farmers to pay back loans granted under the revolving fund. Consequently, the continued viability of the fertilizer revolving fund depends mainly on the yield and sale of this crop. Any new technology that enhances yields and profitability is likely to be adopted by the farmers. As of now, the main constraints to the production of this crop and other cereals as perceived by farmers are as follows:

   a. Some cultural practices such as sowing and harvesting are very labor-intensive and time-consuming, and these in turn increase the cost of production. Mechanization of these techniques, even if partial, is therefore advisable.

   b. Increases in fertilizer application sometimes lead to a food glut in local markets; hence, the sale of farm produce becomes a problem. Farmers therefore prefer to stock their produce to enable them to wait for 5 to 6 months before they sell at profitable prices. This underscores the need for a warehouse, and to some extent a search for larger markets. The search for outlets should extend beyond northern Nigeria, where at the moment the bulk of farm produce is sold. Farmers will welcome any assistance from the project in this direction.

Future Prospects of the Project

The project's prospects are twofold:

1. Prospects with respect to the fertilizer bank (long-term):

   - Envisage the construction of a warehouse in the experimental village.

   - Intensify the training of the management committee of the farmers' association through a

Table 2. Operation of the Fertilizer Revolving Fund in Tchizon, 1989-91

Year	Fertilizer Loaned			Recovery	
	Type	Quantity	Cost	Amount	%
		('000 mt)	('000 FCFA)	('000 FCFA)	
1989	SSP + urea	365.7	18,283.5	10,250.4	56.1
1990	SSP + urea	164.0	7,200.0	6,200.0	86.1
1991	SSP + urea	163.1	6,559.5	In progress	

Source: Records of Farmers' Association.

comprehensive program during the 1991/92 cropping season.

- Broaden the cooperative's activities to include extension of credit facilities to cover modern farm implements.
- Conduct research focusing on appropriate methods of harvesting tiger nuts.
- Motivate farmers to diversify into the production of other cash crops in addition to tiger nuts.
- Establish a producer price policy and, if possible, remove market intermediaries in the sale and distribution of cereals.
- Extend the project to other districts and villages in the Maradi region.
- Address the issue of an agricultural credit facility by creating a "mutual benefit society" type of fund.
- Consider the creation of a farm produce insurance scheme (covering disaster risks).

2. Prospects with respect to field work:

- Motivate and encourage national research personnel in the dissemination of research findings (publications, training schemes, symposia).
- Intensify studies in the area of water pollution.
- Address the problems of water and wind erosion.
- Intensify studies on the problems encountered by women on the farms.

Discussion

Dr. Riedacker commended the SFRP implementation team for the work done in the light of the problems encountered. After expressing a similar positive sentiment, Mr. Denis added that, in general, 3 years of field work is not enough to allow an in-depth evaluation of project impacts. He emphasized in particular that, from his own experience, it will require no less than 5 years of continuous field work to assess in a meaningful way the effects of fertilizer use on the environment. Therefore it would be prudent for donors to provide support for a second phase of the project to allow a detailed assessment of consequences of fertilizer use on the human and physical environments. He added that the outcome of such analyses should be more useful to policymakers in formulating policies about fertilizer use.

Commenting on the issue raised by Mr. Denis, Dr. Fube added that, because donors as well as the general public are increasingly pushing environmental issues on the development agenda, greater emphasis should be placed on environmental conservation during the second phase of the project. He suggested, for example, that the project should consider embarking on soil conservation programs in those villages where soil fertility has been restored.

On the question of emergent lifestyles of some project farmers, especially in northern Togo, it was suggested that extension officers should advise farmers to cut down their expenditures on consumer durables and invest more on their farms in the form of agricultural inputs. Dr. Thompson did not share this view. He suggested that such an issue should be handled with caution because sometimes such interventions can be counterproductive. He stressed that some farmers may even interpret it as a direct interference in their private affairs. Dr. Acheampong drew the group's attention to the multiple role that a bicycle, for example, plays in the economic and social life of a farmer. He reiterated that a bicycle should not be seen only as a status symbol but also as a dependable means of transporting the farmer to the farm, market, clinic, and sometimes to the regional capital for essential inputs. Therefore, farmers should not be advised against owning bicycles if they have the means to do so.

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Sustainable Nutrient Management/Soil Conservation Systems Within Watersheds: A Project Proposal

E. R. Rhodes, Agronomist (SFRP Team Leader),
IFDC-Africa, Lomé, Togo

West African farmers are mining plant nutrients from croplands, and the food crises now facing the region will worsen unless appropriate agricultural production practices are adopted to increase production, conserve the soil, and reverse the decline in soil fertility.

The general objective of the proposed project is to identify and promote systems of plant nutrient management and soil/water conservation adapted to farmers' circumstances in selected pilot villages of West Africa. Such systems should (a) boost crop production substantially, (b) help farmers increase incomes, (c) prevent further degradation of farmlands, and (d) result in sustainable food and cash crop production.

The specific objectives are as follows:

1. To study the interactive effects of mineral fertilizers and organic materials on crop performance and the physical and chemical properties of the soils in selected land units within watersheds.

2. To determine the physical and socioeconomic characteristics of the pilot villages and study the constraints to the adoption of fertilizers, organic materials, and soil/water conservation practices.

3. To evaluate the effects of fertilizers and organic materials on the conservation of the resource base and the environment.

4. To identify and promote, in partnership with farmers and personnel of the National Agricultural Research and Extension Systems (NARES), the adoption of appropriate plant nutrient management and soil/water conservation technologies targeted to specific groups of farmers in pilot villages.

5. To assess the implications of pilot village research results for agricultural development at the regional level.

6. To develop a spatial and computerized land use data base.

7. To train national research and extension workers and farmers in improved methods of plant nutrient management and soil/water conservation.

8. To strengthen/develop linkages between national research personnel, extension workers, the national soil conservation unit, the national agricultural policy unit, and farmers.

The project focuses on lands of the West African Savanna that need to be carefully managed to prevent degradation and preserve the environment. Major activities will be based in the Guinea and Sudan Savanna zones (three villages in the pilot area) of two West African countries with some trials distributed in three other West African countries through a networking system. Research and development efforts will commence on sites that are still productive but susceptible to degradation. It will involve work at both the individual farmer's holding and the watershed level.

A guiding principle in the design of the trials and experimental production plots will be the need to maximize the use of biologically fixed N, optimize the efficiency of mineral fertilizers and the production of above- and below-ground plant biomass, utilize crop residues, and conserve soil nutrients in West African farming systems.

Discussion

Dr. Mokwunye summarized the salient components of the proposed project as presented by Dr. Rhodes. In particular, he drew the group's attention to its holistic and participatory nature and invited ideas, comments, and suggestions to improve it. He cautioned that in doing so the group should examine the proposed project within the context of an integrated rural development project.

Comments and suggestions from the group pertaining to the objectives, methodology, and scope of the proposed project were generally positive. A summary of some of the salient points and suggestions for improving the project follows.

1. **Objective**
   Some loose ends in the specific objectives need to be tied down; the focus needs to be sharpened a little further to address current environmental concerns of donors and the general public.

2. **Methodology**
   The proposed conservation methods should be simple and the technologies inexpensive in order to enhance farmer adoption; livestock development should be integrated in the project to allow achievement of forward and backward linkages of project outputs; the possibility of using organic wastes from urban centers as soil amendments should be explored; trial plots should be large enough to generate income to support other project activities.

3. **Scope of Work**
   The idea of creating a steering committee to guide the proposed project is very laudable; however, steps should be taken to avoid creating a "super" bureaucracy that may impede project implementation; the role of nationals should be specified clearly to avoid confusion or conflict; and finally, the focus of the project should be sharpened.

Regarding possible sources of funding for the proposed project, Dr. Pieri hinted that the European Community may be willing to provide funding, provided the project (1) is given a regional focus and is not expensive to implement, (2) falls in line with the development priorities of host governments, (3) is targeted at critical areas so that investments made can be recouped through the sale of cash crops, and (4) is presented as a joint effort between IFDC-Africa and host governments.

Closing Address

Christian Pieri, Director of Research,
CIRAD, Paris, France

We are about to conclude the deliberations of a workshop that has brought together, during the past week, 42 participants from 13 countries in Africa, Europe, and North America.

We assembled here to share experiences acquired during 3 years of the Soil Fertility Restoration Project, and we have effectively analyzed "constraints to fertilizer use at the village level." This project was undertaken under the auspices of IFDC in collaboration with research and development institutions in Niger, Togo, and Ghana. From the various presentations and ensuing discussions, we have been able to assess the scope of the project as well as the methods used in its implementation. In short, we have discussed the merits and shortcomings of the project. I should emphasize that the other objective of the organizers as well as the various institutions whose financial support has made the workshop possible—namely, IFDC-Africa, CIRAD, the French Ministry of Cooperation, IMPHOS, and APF—was to encourage interaction between Francophone and Anglophone research and development professionals, social scientists, administrators, and policymakers who have done us the honor of participating in these deliberations.

I believe we have, to a large extent, achieved these objectives as indicated by the frank and open discussions during the past few days.

The workshop was conducted in a congenial atmosphere. We were not denied the traditional hospitality and friendship of the people of Togo even though the country is experiencing tremendous political and socioeconomic changes unparalleled in its checkered political history. The task of the organizers has not been easy, nor, as we have realized, has it been easy to conduct complex research work with farmers outside the secure environment of research stations. Although the journey from the south to the north of Togo was long and the field visit very short, we nonetheless had the rare opportunity to hold discussions as we travelled through this beautiful country. Has it not been said that the most fruitful moments of any seminar or conference are the informal out-of-session discussions held among participants, which enable them to enhance their knowledge and understanding of one another.

Indeed, we wish to express our sincere gratitude to all our colleagues through whose efforts this workshop was organized. We are equally grateful to all those who made presentations and those who participated in the discussions, and we hope that we will have more opportunities to meet and work together in future.

In fact, the task to be accomplished is enormous, and we need to mobilize all our energies and transcend linguistic barriers in order to define and pursue strategies on the use of fertilizers for the restoration and preservation of soil fertility in Africa.

We are all aware of the urgent and complex nature of these problems. Although I do not intend to present a comprehensive summary of our discussions, observations, and proposals here, I would nevertheless wish to comment on some of the salient points highlighted in the course of our deliberations.

In the first place, with regard to the objective of such a research project in a farming community, it has become increasingly clear that a project of this nature should, and can, provide decisionmaking elements to two large important sociological groups, namely, farmers and decisionmakers at the national and international levels. This is not an easy task because the elements differ in nature, whether they are the types whose main objective is the satisfaction of vital needs in the short-term or the types that should be used in drawing up agricultural development strategies over the medium- or long-term.

It is proper for applied research to endeavor to gather useful information for these two groups directly from the field. The project has shown that this could be achieved through a multidisciplinary and regional approach. In other words, the workshop has demonstrated that when

agronomists, economists, and sociologists together study the same experimental or control villages located in three countries representing different agroecologies from the Sahel to the Gulf of Guinea, it is possible to arrive at a consensus. It is in fact through a scientific analysis of concrete agricultural problems that we arrive at this single viewpoint regardless of apparent differences in scientific approach and local situation.

One of us pointed out that the effectiveness of the research work depends basically on the understanding of the complex local systems. Thus, while addressing the issues of the distribution of mineral fertilizers, one is at the same time dealing with the problems relating to the promotion of a sustainable agricultural development. It is no longer just a matter of fertilizing food farms, but rather the necessity of managing a rural environment on a sustainable basis where the cultural and production factors, as well as the land tenure systems and the levels of soil fertility (or degradation), are different.

Whether the solutions identified are applicable will first of all depend on the proper identification of the main problems facing agricultural development. Thus, regardless of its track record, a research institution deviating from scientific analysis to descriptive work or superficial journalism faces risk. In short, any research activity that lacks rigor will ultimately have little impact on farmers, our special customers; neither will it be appealing to decisionmakers, the providers of the necessary financial resources for our research work.

In view of this, there is the need for our institutions to properly identify the research priorities. This in fact is one of the salient points deriving from our discussions. I wish to elaborate on this point as follows.

First, how are these priorities established? We have just pointed out that research priorities should first of all be based on realities in the field. It is significant to note that after 3 years of its existence, the SFRP is capable of designing a new research program and defining its objectives because it has become thoroughly conversant with the local farming systems and the specific expectations of the various groups of farmers.

This poses the problem of both the approach to the research aspect of this type of project and the schedule of the field activities to be undertaken so that the trials, for instance, help to compare the methods considered as the most effective on the basis of the results of the preliminary field work. It also presupposes that donors should be convinced about the effectiveness of this comprehensive approach in order to address in a more appropriate manner a significant number of problems, relating to soil fertility and the plant nutrients, that have been properly identified as priorities for agricultural development. In fact it presupposes that we should be able to present genuine and valid arguments that are likely to generate a favorable response from our sponsors.

In addition, we are aware that these priorities should be based on an exhaustive literature review. Ours is not the beginning of agricultural research work. In fact for many years research has been conducted by several national, regional, and international institutions. We are also aware that research officers of some of our organizations do not always make the necessary effort to assemble and analyze past bibliographical sources. It is true that information is rather difficult to find because the sources are not catalogued and are therefore unknown.

It appears obvious that IFDC-Africa, which began to compile existing bibliography on fertilizers in Africa, has an important role to play in order to become the most comprehensive documentation center on this subject in the French and English languages. May I also express the wish that, in conformity with the changes in IFDC's mandate, this documentation center of the Africa Division will compile available information on all the fertilizing agents (mineral, organic, biological) and on the chemical fertility of soils, which is more extensive in scope than the information on mineral fertilizers alone. Let us hope that such a regional documentation center will be established and that the modest center that IFDC-Africa currently runs will be able to find the necessary financial resources to attain this new dimension.

This in-depth bibliographical analysis, a prerequisite to proposed activities relating to the definition of priorities, is therefore imperative. This analysis will be facilitated if our scientific community becomes more committed to the analysis and updating of existing written works and the editing of scientific publications and documents for the benefit of all the people in Francophone and Anglophone Africa. Nothing will be more disappointing and incompatible with our profession as research workers than to give the impression to agricultural policymakers and donors that we are "reinventing the wheel."

My second observation is that a project of this type can also have a more ambitious objective, that of demonstrating on a larger scale that a sustained management of farmlands can contribute effectively to maintaining a congenial environment for humankind. We

are all in favor of a joint harmonious relationship between development and the environment. Deforestation, and its impact on climatic changes throughout the world, is increasingly arousing public and international opinion.

It is about time we demonstrated that increasing the agricultural productivity of farmlands is certainly an effective way of checking or at least slowing down the rate of deforestation. It is also the only condition for maintaining not only the quality of the atmosphere but also that of the soil, which perhaps is the most endangered natural resource of farmers in developing countries. In these countries, the worst form of pollution is either the irreparable damage to land caused by erosion or soil degradation resulting from the persistent decline in the chemical reserves of the soil or its biological life. It is necessary to undertake an agroeconomic assessment of the decline in the soil's fertility using objective and measurable criteria. In fact it will be realized in future that failure to fertilize farm lands properly under the pretext that it would not be profitable within the short-term would inevitably lead to dramatic situations. The economic and social costs (rural exodus and overcrowding in urban areas) will definitely outstrip the cost involved in an integrated management of plant nutrients to ensure that soil and water quality are preserved.

I would have added several other comments to this concise presentation of some of the points that appeared important to me during our deliberations, but the time has come to close this workshop.

I thank you for participating so actively and hope that we will meet again to review progress in removing the constraints to the use of fertilizer to ensure that farming continues on a sustainable basis in Africa.

Workshop Participants

Benin
Jonas Akle

Cameroon
Howard Fube

Burkina Faso
Sekou Marc Bitibaly
Guy Faure
Victor Hien

Côte d'Ivoire
Koutouan Djava
Losseny Dosso
Soumaïla Traore

Ghana
Peter Agyili
Edward Albert Denis
Samuel Opoku
E. S. Otinkorang

Mali
Demba Kebe
Mamadou Kabirou Ndiaye
Abdoulaye Traore

Morocco
Abdelatif Belemehdi
Abderrahim Nassir

Senegal
Aminata Badiane
Safietou Fall
Valeri Kelly
Papa Leopold Sarr

Togo
Komlan Abalo
L. K. Allaglo
Ayele Mawuto Gninofou
Komi Amouzou Somana
Tchabli Nayebe Tiem

CIRAD/France
Michel Benoit-Cattin
Christian Pieri
Arthur Riedacker

IFDC-Africa
Konadu Acheampong
A. Mawuli Alognikou
Elias Ayuk
Uzo Mokwunye
Amoui N'Danou
D. Pierre
Denis Pouzet
Edward Rhodes
Anani Sakiti
Joseph Sedgo

IFDC, Muscle Shoals, U.S.A.
Carlos A. Baanante
Thomas P. Thompson

Niger
S. Bawa
Ahmadou Ndiaye
Marou Assane Zarafi

Nigeria
Abraham Oyediji Ogunbile

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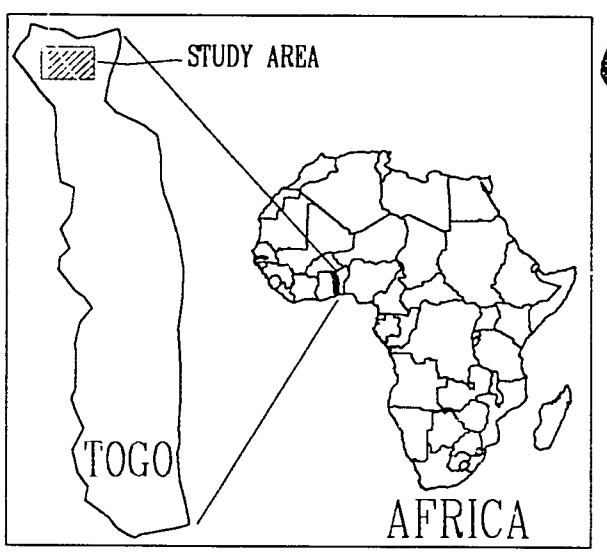
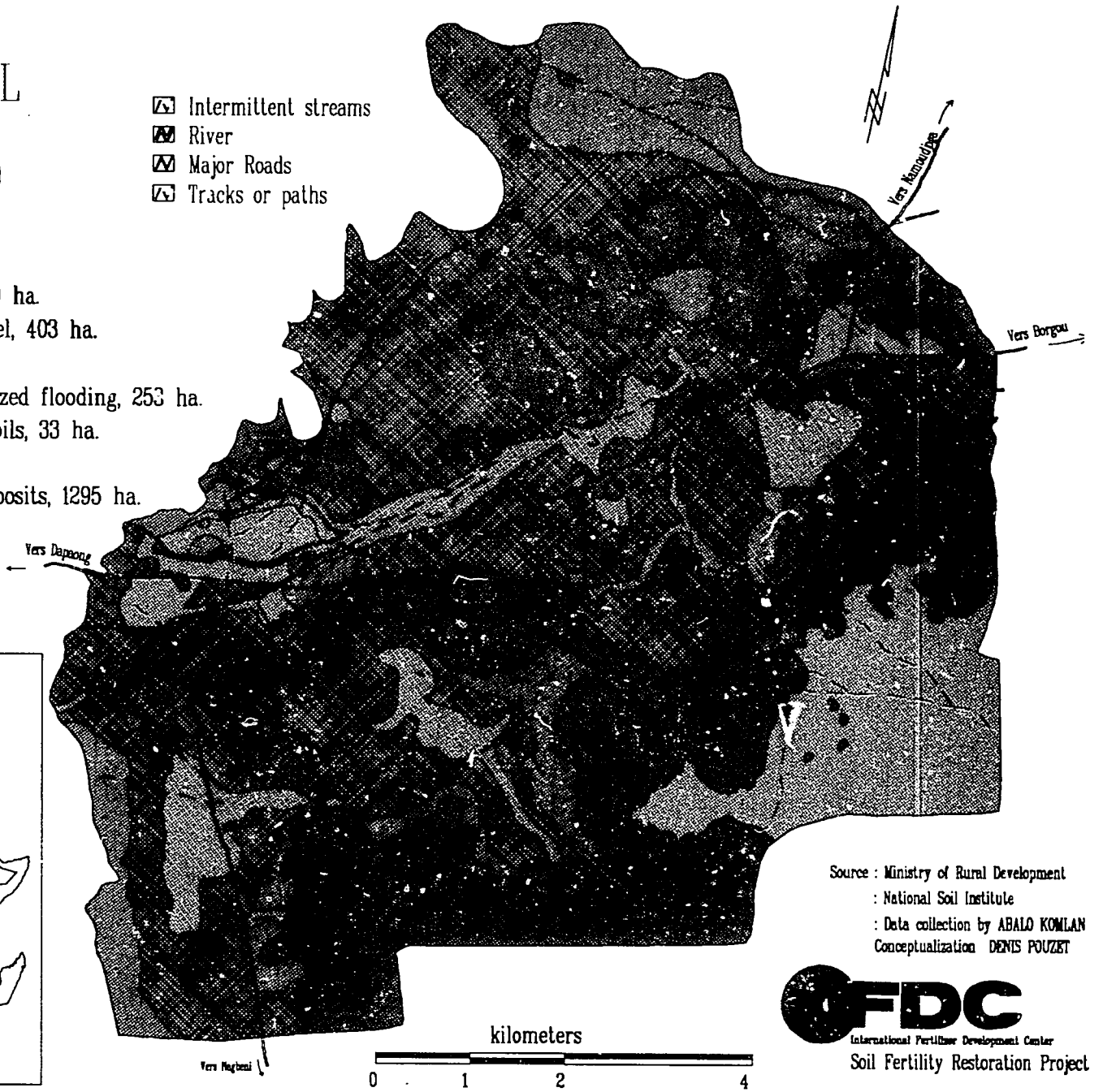
SOIL TYPES
SECTOR OF KPENDJAL
DISTRICT OF TONE
Village of Naki-Est (Nakitindi-Lare)

- Mine, access use corridor, 3 ha.
- Mountainous or hilly, 845 ha.
- Leached and poor ferruginous soils, 70 ha.
- Ferruginous soil with compacted gravel, 403 ha.
- Leached ferruginous soil, 321 ha.
- Lowland hydromorphic soil with localized flooding, 253 ha.
- Leached and compacted ferruginous soils, 33 ha.
- Undermined steep banks, 8 ha.
- Poorly developed soil with alluvial deposits, 1295 ha.





Source : Ministry of Rural Development
: National Soil Institute
: Data collection by ABALO KOMLAN
Conceptualization DENIS POUZET

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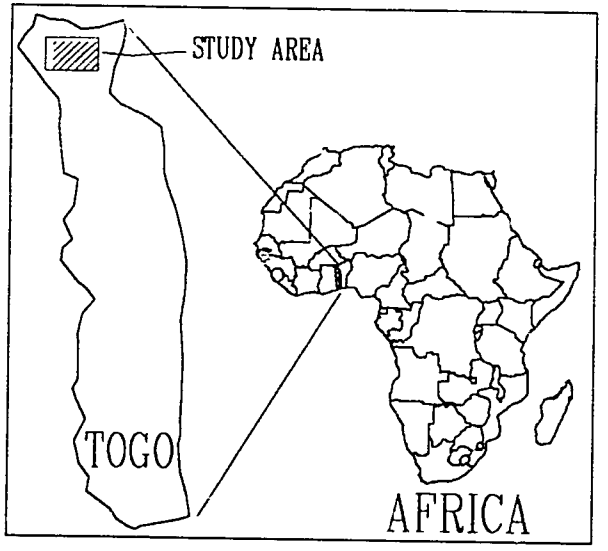
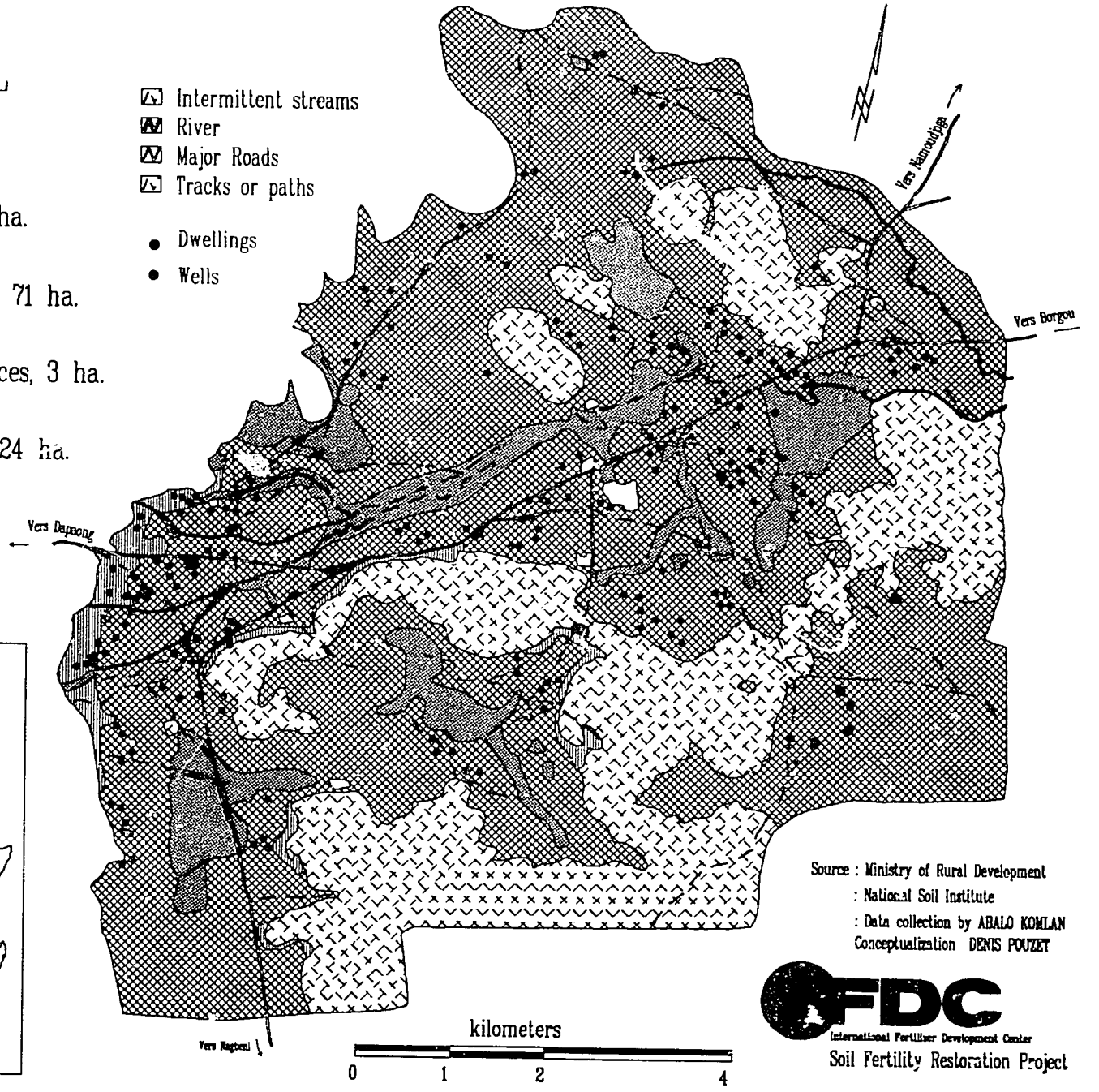
Soil Fertility Restoration Project

LAND USE
SECTOR OF KPENDJAL
DISTRICT OF TONE

Village of Naki-Est (Nakitindi-Lare)

- Mines, access use corridor, 3 ha.
- Cultivated land, 1989 ha.
- Cultivated land with terraces, 71 ha.
- Mountain range, 843 ha.
- Surface rock flush with terraces, 3 ha.
- Grazing commons, 35 ha.
- Partially cultivated lowland, 224 ha.
- Lowland pasture, 53 ha.
- Teakwood forest, 8 ha.
- Cashew trees, 2 ha.





Source : Ministry of Rural Development
: National Soil Institute
: Data collection by ABALO KOMLAN
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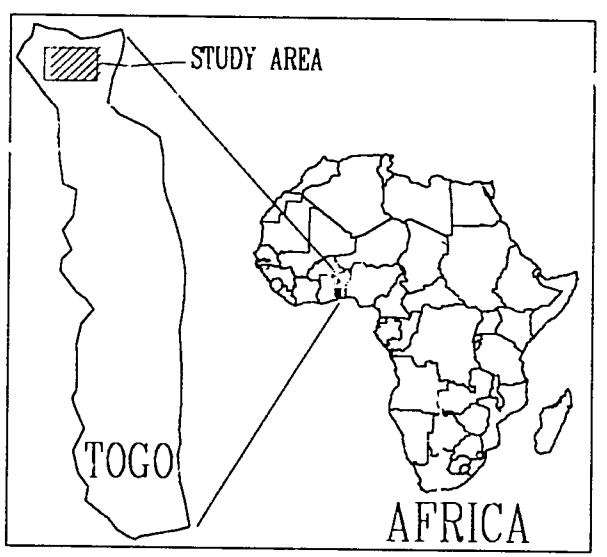
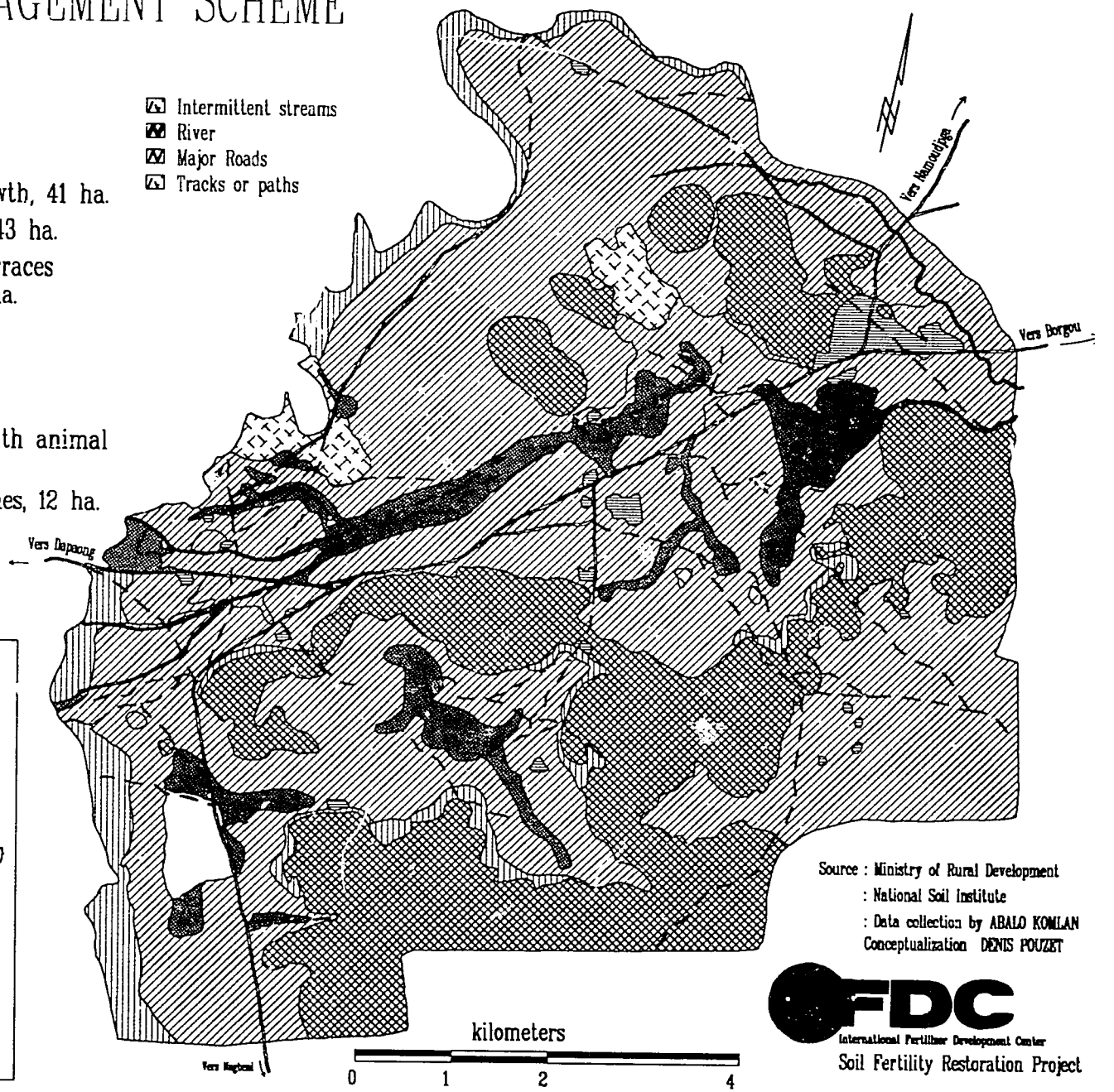
PROPOSED LAND MANAGEMENT SCHEME
SECTOR OF KPENDJAL
DISTRICT OF TONE

Village of Naki-Est (Nakitindi-Lare)

- Reforested area for rapid timber growth, 41 ha.
- Localized reforested protected area, 843 ha.
- Construction and rehabilitation of terraces with cultivation by corridors, 183 ha.
- Cultivation by contour lines, 1841 ha.
- Pasture, 58 ha.
- Rice cultivation, 227 ha.
- Improvement of land and pastures with animal forage species, 28 ha.
- Stone placement at the head of ravines, 12 ha.





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