International Fertilizer Development Center Annual Report, 1996

"Creating Fertile Soil for a Food-Secure World"

IFDC's Mission

To increase and sustain food and agricultural productivity in developing countries through the development and transfer of effective and environmentally sound plant nutrient technology and agribusiness expertise.

Strategic Goals

- To conduct strategic and applied research that seeks to enhance plant nutrient efficiency.
- To transfer and implement improved plant nutrient technology.
- To assist in the development and implementation of economic policies that promote open, competitive markets.
- To help strengthen national institutions through the transfer of technology and the development of the human capacity in developing countries.
- To ensure the complementarity of international and national research efforts through close collaboration with national agricultural research systems and other international agricultural research centers (IARCs).
- To conserve the natural resource base and the environment.
- To promote food security and poverty alleviation through the integrated management of plant nutrients and natural resources.

Clients/Beneficiaries of Our Work

- Farmers in the developing countries and the newly independent states of Eastern and Central Europe and the former Soviet Union
- Developing-country researchers and extension officers
- Policymakers
- Agribusinesses

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This happy farmer in Kapasia Zone (Bangladesh) fertilized his field with urea supergranules under the Agro-Based Industry and Technology Development Project (ATDP) promotion program and received a substantially higher yield.

Acronyms

advanced research organizations (AROs)
agribusiness credit fund (ACF)
Agro-Based Industry and Technology Development Project (ATDP)
Albanian Fertilizer and Agribusiness Dealers' Association (AFADA)
Automated Land Evaluation System (ALES)
Bureau of Alcohol, Tobacco, and Firearms (BATF)
Centro de Energia Nuclear na Agricultura (CENA)
Centro Internacional de Agricultura Tropical (CIAT)
Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)
Centro Nacional de Pesquisa de Agrobiologia (CNPAB)
Collaborative Research Support Program (CRSP)
Consultative Group on International Agricultural Research (CGIAR)
Cooperation in Applied Science and Technology (CAST)
Decision Support System for Agrotechnology Transfer (DSSAT)
Development of Ecoregional Methodologies (DME)
Directoraat Generaal voor International Samenwerking (DGIS)
Ecoregional Programme for the Humid Tropics of Africa (EPHTA)
Egyptian Fertilizer Development Center (EFDC)
Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA)
encapsulated calcium carbide (ECC)
Entreprise Nationale du Fer et du Phosphate (FERPHOS)
Environment, Culture, Agriculture, Research and Development Society (ECARDS)
Environmental Protection Agency (EPA)
Fertilizantes de Minatitlan SA. de C.V. (FERTIMINA)
Fertilizantes Quimicos Mexicanos (FERQUIMEX)
Food and Agriculture Organization of the United Nations (FAO)
Geographic Information System (GIS)
international agricultural research centers (IARCs)
International Centre for Research in Agroforestry (ICRAF)
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
International Development Center of Japan (IDCJ)
International Fertilizer Development Center (IFDC)
International Fertilizer Industry Association (IFA)
International Food Policy Research Institute (IFPRI)
International Fund for Agricultural Development (IFAD)
International Potato Center (CIP)
International Rice Research Institute (IRRI)
Ministry of Agriculture and Food (MOAF)
Mississippi State University (MSU)
National Aeronautics and Space Administration (NASA)
National Agricultural Research Center – Uruguay (INIA)
national agricultural research systems (NARS)
Petroquimica de Venezuela SA. (PEQUIVEN)
Research Institute for Agrobiology and Soil Fertility (AB-DLO)
Soil Fertility Initiative (SFI)
Soil Fertility Management Unit (SFMU)
Soil, Water, and Nutrient Management (SWNM)
Standards and Industrial Research Institute of Malaysia (SIRIM)
Support for Agricultural Restructuring in Albania (SARA)
The Fertilizer Institute (TFI)
Tropical Soils Biology and Fertility program (TSBF)
United Nations Industrial Development Organization (UNIDO)
United States Agency for International Development (USAID)
United States Department of Agriculture (USDA)

Preface

Sorghum and millet production in the overpopulated Dogon country of Mali. Moving dunes are threatening food production.

As we near the next millennium, the International Fertilizer Development Center (IFDC) is confronted with the task of offering potential solutions to a variety of emerging issues. Approximately 850 million people in the world do not have sufficient food to maintain a healthy diet. On a crowded planet, poverty is a primary impediment to food security and good health; the poor lack the means to obtain food in adequate quantities for a healthy life.

In improving nutrition agriculture plays an important role, first due to its principal role in producing food of the required quantity and quality and second to its direct/indirect role of providing employment and income to the poor, particularly in the developing countries. One of agriculture's vital keys to the development of global food security is soil fertility. To create a "fertile soil for a food-secure world" requires a dependable supply of plant nutrients and the adoption of techniques to effectively manage them. Sources of nutrients may include inorganic materials in the form of mineral fertilizers and organic materials such as crop residues, green manures, animal manures, and agroindustrial wastes. A concept that encourages the use of organic sources and the well-timed, strategic use of mineral fertilizers is commonly referred to as integrated nutrient management. Integrated nutrient management represents a sustainable and ecologically sound approach to managing farming systems. Whereas mineral fertilizers facilitate the cost-effective management of specific nutrients, organic sources not only add nutrients but also improve the soil's physical and biological properties. To be successful, however, integrated nutrient management must be based on a quantitative understanding of crop nutrient requirements, the nutrient-supplying capacity of the soil, and the nutrient-supplying capacity of the added sources of nutrients.

To help ensure sustained agricultural production to meet the nutrition needs of a growing population, IFDC is joining forces with several other international agricultural research organizations, multilateral and bilateral development agencies, trade agencies, nongovernmental organizations, and private sector companies to reverse the trend of declining soil fertility, especially in sub-Saharan Africa. In its efforts, IFDC is applying the integrated nutrient management approach to increase food productivity while maintaining its focus on natural resource management and environmental conservation. Another key component of IFDC's work concerns market development – the

development of an open and competitive market system reduces costs for farmers and generates employment opportunities, thus ensuring a more food-secure population. Equally important is the emphasis on human capacity building; IFDC is constantly upgrading and diversifying its training opportunities to meet the changing needs of a dynamic agriculture sector.

As a new venture during 1996, IFDC established a presence on the World Wide Web to enhance its outreach to the global community and to further disseminate information on all of its programs. This site can be accessed at www.ifdc.org.

During 1996 a number of staff changes occurred. Dr. Hendrik Breman, former Head of the Department of Agrosystems Research of the Research Institute for Agrobiology and Soil Fertility (AB-DLO) of the Netherlands, succeeded Dr. Uzo Mokwunye as Director of the IFDC-Africa Division. Mr. Jorge R. Polo, former Coordinator of the Engineering and Technology Program, succeeded Mr. James J. Schultz as Director of the Outreach Division. Mr. Ram S. Giroti was promoted to Director of the Human Resource Development Unit.

During the 1996 Board Meeting, Mr. Al Giese, Vice President – Agronomy, Cenex/Land O'Lakes, was welcomed as a new member of the IFDC Board of Directors.

In 1996 the demand for IFDC's services continued to expand. With continuing support from its loyal group of donors and through greater collaboration with both national and international institutions, IFDC will continue to be a vital force in the agricultural development arena.

We are pleased to present this annual report, which is organized around the theme, "Creating Fertile Soil for a Food-Secure World." The short executive summary is intended for the very busy reader. Our French- and Spanish-speaking colleagues will find a translation of the "Preface" and "Executive Summary" in their languages by turning to the color-screened sections.

W. David Hopper
Chairman
IFDC Board of Directors

Amit H. Roy
IFDC President and Chief Executive Officer

Prefacio

La producción de sorgo y millo en los campos superpoblados de Dogon en Mali. Las dunas ambulantes están amenazando la producción de alimentos.

A medida que nos acercamos al próximo milenio, el Centro Internacional para el Desarrollo de Fertilizantes (IFDC) afronta la tarea de ofrecer soluciones potenciales a una variedad de temas que están emergiendo. Aproximadamente 850 millones de personas en el mundo no tienen suficientes alimentos para mantener una dieta saludable. En un mundo superpoblado, la pobreza es el impedimento principal en lograr una seguridad alimenticia y buena salud; la gente pobre carece de medios para obtener alimentos en cantidades adecuadas para llevar una vida saludable.

En el mejoramiento de la nutrición, la agricultura juega un papel importante, primero debido a su papel principal en la producción de alimentos en la cantidad y calidad requeridas y segundo en su papel directo e indirecto de proveerle empleo e ingresos a los pobres, particularmente en los países en vías de desarrollo. Una de las claves vitales para el desarrollo de la seguridad alimenticia es la fertilidad de los suelos. El crear "suelos fértiles para un mundo con seguridad alimenticia" requiere un suministro consistente de nutrientes agrícolas y la adopción de técnicas que los administre efectivamente. Las fuentes de nutrientes pueden ser materiales inorgánicos en forma de fertilizantes minerales, o materiales orgánicos como residuos de cosechas, estiércoles verdes, estiércoles de animales y desechos industriales. Un concepto que estimula el uso de fuentes orgánicas y el oportuno uso estratégico de fertilizantes minerales, se conoce comúnmente como el manejo integrado de nutrientes. El manejo integrado de nutrientes representa un enfoque sustentable y ecológicamente razonable para manejar los sistemas de cosechas. Así como los fertilizantes minerales facilitan el manejo de ciertos nutrientes específicos en forma económica, las fuentes orgánicas no sólo añaden nutrientes sino que también mejoran las propiedades físicas y biológicas del suelo. Para tener éxito, sin embargo, el manejo integrado de nutrientes se debe basar en un conocimiento cuantitativo de los requerimentos de nutrientes de los cultivos, de la capacidad del suelo para suministrar nutrientes, y de la capacidad de suministro de las fuentes de nutrientes añadidos.

Para ayudar a asegurar la producción agrícola sostenida y cumplir con las necesidades nutricionales de una población creciente, el IFDC se está uniendo a otras organizaciones internacionales de

investigación agrícola, agencias de desarrollo multilaterales y bilaterales, agencias de comercio, organizaciones no gubernamentales, y empresas del sector privado para cambiar la tendencia decreciente de la fertilidad de suelos, especialmente en el sub-Sahara africano. En sus esfuerzos, el IFDC está aplicando el sistema de manejo integrado de nutrientes para aumentar la productividad de alimentos, a la vez que mantiene su enfoque en el manejo de recursos naturales y la conservación ambiental. Otro componente clave del trabajo del IFDC se relaciona con el desarrollo de la comercialización – el desarrollo de un sistema competitivo de libre mercado reduce el costo a los agricultores y genera oportunidades de empleo, asegurando una población con seguridad alimenticia. Es igualmente importante el énfasis sobre el desarrollo de capacitación humana; el IFDC constantemente está actualizando y diversificando sus oportunidades de entrenamiento para cumplir con las necesidades cambiantes de un sector agrícola dinámico.

Como nuevo proyecto durante 1996, el IFDC estableció su presencia en la World Wide Web para acrecentar su servicio de extensión a la comunidad global y para diseminar mejor la información sobre sus programas. Este sitio puede ser accesado en www.ifdc.org.

Durante 1996 ocurrieron una serie de cambios de personal. El Dr. Hendrik Breman, anteriormente Jefe del Departamento de Investigación de Agrosistemas del Instituto de Investigación sobre Agrobiología y Fertilidad de Suelos (AB-DLO) de los Países Bajos, reemplazó al Dr. Uzo Mokwunye como Director de la División IFDC-Africa. El Sr. Jorge R. Polo anteriomente Coordinador del Programa de Ingeniería y Tecnología, reemplazó al Sr. James J. Schultz como Director de la División de Extensión. El Sr. Ram S. Giroti fue promovido a Director de la Unidad de Desarrollo de Recursos Humanos.

Durante la Junta Directiva de 1996, el Sr. Al Giese, Vicepresidente de Agronomía, Cenex/Land O'Lakes, fue recibido como nuevo miembro de la Junta Directiva del IFDC.

En 1996 la demanda por los servicios del IFDC continuó expandiendo. Con el continuo apoyo de su grupo fiel de donantes y a través de una mayor colaboración con instituciones tanto nacionales como internacioales, el IFDC continuará siendo una fuerza vital en el ruedo del desarrollo agrícola.

Nos sentimos complacidos en presentar este informa anual, el cual está organizado en base al tema "Creando Suelos Fértiles para un Mundo con Seguridad Alimenticia." El corto resumen ejecutivo es para los lectores muy ocupados. Nuestros colegas francohablantes e hispanohablantes encontrarán una traducción del "Prefacio" y del "Resumen Ejecutivo" en sus idiomas en las secciones a color.

W. David Hopper
Presidente de la Junta Directiva del IFDC

Amit H. Roy
Presidente y Jefe Ejecutivo del IFDC

Preface

Culture de mil et de sorgho en pays Dogon, une région surpeuplée du Mali. Les dunes mouvantes constituent une menace pour la production vivrière.

A l'approche du troisième millénaire, le Centre International pour la Gestion de la Fertilité des Sols (IFDC) fait face à l'exigence d'offrir des réponses possibles à une série de problèmes qui interpellent les consciences et les esprits. Environ 850 millions de personnes dans le monde ne disposent pas des vivres nécessaires pour assurer leur bien-être nutritionnel. Sur notre planète surpeuplée, la pauvreté est le principal obstacle à la sécurité alimentaire: les populations défavorisées n'ont pas les moyens de se procurer une nourriture suffisante pour mener une vie saine.

L'importance de l'agriculture dans l'amélioration de la situation nutritionnelle vient, en premier lieu, de son rôle principal qui est de produire des denrées alimentaires en quantité et en qualité adéquates, et, en second lieu, de son rôle dans la fourniture directe et indirecte d'emplois et de revenus aux populations rurales, particulièrement dans les pays en développement. L'un des facteurs clés du développement de la sécurité alimentaire mondiale est la fertilité des sols. "Développer des sols fertiles pour la sécurité alimentaire dans le monde" implique l'utilisation de sources fiables d'éléments nutritifs et l'adoption de techniques efficaces pour leur gestion. Parmi les sources d'éléments nutritifs figurent des produits inorganiques sous la forme d'engrais minéraux et des produits organiques tels que les résidus de culture, les engrais verts, le fumier d'animaux et les déchets agro-industriels. L'approche qui associe l'utilisation des sources organiques à l'application judicieuse des engrais minéraux est communément appelée gestion intégrée des éléments nutritifs. Cette approche est économiquement et écologiquement viable pour la gestion des systèmes agricoles. Si les engrais minéraux facilitent la gestion efficace d'éléments nutritifs spécifiques, les sources organiques non seulement apportent des éléments nutritifs mais encore améliorent les propriétés physiques et biologiques des sols. Cependant, le succès de la gestion intégrée des éléments nutritifs suppose une compréhension quantitative des besoins en éléments nutritifs des cultures ainsi que de la capacité du sol et des sources additionnelles à fournir ces éléments.

Pour aider à assurer une production agricole durable qui permette de couvrir les besoins d'une population mondiale en pleine expansion, l'IFDC unit ses forces à celles de diverses organisations internationales de recherche, des agences bilatérales et multilatérales de développement, des agences commerciales, des organisations non gouvernementales, et des compagnies du secteur privé, afin

d'inverser la tendance au déclin de la fertilité des sols particulièrement en Afrique subsaharienne. Dans le cadre de ces efforts, l'IFDC applique l'approche de gestion intégrée des éléments nutritifs pour accroître la productivité vivrière tout en mettant l'accent sur la gestion des ressources naturelles et la protection de l'environnement. Un autre volet clé de l'action de l'IFDC porte sur le développement de marché - le développement d'un marché ouvert et compétitif permet de réduire les coûts pour les agriculteurs et de créer des possibilités d'emploi, contribuant ainsi à une plus grande sécurité alimentaire pour les populations. L'accent est également mis sur le développement des ressources humaines: dans cette optique, l'IFDC améliore et diversifie continuellement ses capacités de formation afin de mieux répondre aux besoins d'un secteur agricole dynamique.

En 1996, L'IFDC a établi une présence sur le web mondial pour développer son antenne dans la communauté universelle et offrir une vaste gamme d'informations sur tous ses programmes. Le site IFDC est accessible à www. ifdc.org.

L'année 1996 a vu un certain nombre de changements au niveau du personnel de l'IFDC. Dr. Hendrik Breman ancien Directeur du Département de la recherche sur les agrosystèmes de l'Institut de recherche pour l'agrobiologie et la fertilité des sols (AB-DOL) des Pays-Bas remplace Dr. Uzo Mokwunye comme Directeur de la Division pour l'Afrique IFDC-Afrique; M. Jorge R. Polo, ancien coordinateur du Programme de technologie et d'ingénierie succède à M. James Schultz au poste de Directeur de la Division de vulgarisation. M. Ram S. Giroti a été promu Directeur de l'Unité de développement des ressources humaines.

Le Conseil d'administration de 1996 a accueilli un nouveau membre en la personne de M. Al Giese, Vice-président - agronomie, Cenex/Land O'Lakes.

Concernant les services de l'IFDC, la demande a continué à progresser durant l'année 1996. Avec l'appui soutenu d'un groupe loyal de donateurs et une collaboration plus étroite avec les institutions tant nationales qu'internationales, l'IFDC continuera d'être une force motrice dans le domaine du développement agricole.

Nous avons donc le plaisir de présenter ce rapport annuel qui s'articule autour du thème; "Développer des sols fertiles pour la sécurité alimentaire dans le monde." Un résumé analytique a été préparé à l'intention des lecteurs très occupés. Nos collègues francophones et hispanophones trouveront une version de la préface et du résumé analytique dans leurs langues respectives en se rapportant aux sections indiquées en couleur.

W. David Hopper
Président du Conseil d'administration

Amit Roy
Président, directeur général de l'IFDC

Board of Directors

Front row (seated, from left to right): Mr. Luc M. Maene (Belgium); Dr. Bukar Shaib (Nigeria); Mr. George Like (USAID); Mr. Baba Dioum (Senegal); Mr. Vincent McAlister (Secretary to the Board); and Mr. Al Giese (U.S.A.). Back row (from left to right): Mr. Joseph C. Wheeler (U.S.A.); Mr. Charles Sloger (USAID); Dr. W. David Hopper (Canada); Dr. Christian Pieri (France); Dr. Ann P. Hamblin (Australia); Dr. Kunio Takase (Japan); Mr. Pratap Narayan (India); Dr. Norman Borlaug (U.S.A.); Mr. Gary D. Myers (U.S.A.); Dr. Robert E. Wagner (U.S.A.); and Dr. Amit H. Roy (IFDC President and CEO).

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Executive Summary

The restoration and enhancement of soil fertility in low-income, food-deficit countries, especially those of sub-Saharan Africa, is a key component of the development of global food security, sustainable agricultural systems, and thus poverty alleviation. In recognition of the prime importance of soil fertility the theme of this annual report is "Creating Fertile Soil for a Food Secure World."

The following paragraphs summarize IFDC's 1996 activities in the areas of market development, natural resource and environment management, management information systems, and human capacity building.

Market Development

- The 30-month Agro-Based Industry and Technology Development Project (ATDP) is being implemented by the Government of Bangladesh, the U.S. Agency for International Development (USAID), and a consortium composed of IFDC – as prime contractor, Winrock International, and Ronco Consulting Corporation. The project's goal is to increase productive employment in agriculture and related enterprises through the creation of competitive markets for agriculture and agribusiness inputs, outputs, and technologies. The project is promoting reforms in all areas of Bangladesh policy – industrial and agricultural, fiscal and commercial, foreign investment, and legal and regulatory. Agribusiness ventures are being initiated and existing ones expanded with financing from a US $50 million plus agribusiness credit fund. Technological advancement in agri-industry is being spurred through technical assistance, human resource development, and business contracts.
- In collaboration with Winrock International, IFDC contributed to USAID's Support for Agricultural Restructuring in Albania (SARA) project, which supports food security through a broad-based, market-oriented economic growth program. IFDC has developed within the Ministry of Agriculture and Food's (MOAF) Directorate of Statistics, a comprehensive statistical survey and analysis capability. The Center has provided to Albanian entrepreneurs, three agribusiness modules – Agricultural Commodity Systems, Business Planning and Implementation, and Country Promotion. These modules have been presented to more than 1,500 entrepreneurs and will be institutionalized in the Albanian Fertilizer and Agribusiness Dealers' Association (AFADA) Special Publications unit. A video of the Country Promotion module will be presented to potential investors in the United States, the European Union, Balkan countries, and Middle Eastern markets to attract investment and trade.
- As part of another USAID project entitled "Sustaining the Restructured Fertilizer Subsector in Albania," IFDC developed marketing strategies for fertilizer, crop protection chemicals, and seed; these agricultural input markets have been privatized by members of the IFDC-supported trade association, AFADA. With IFDC's assistance, AFADA members now import and market all of Albania's nitrogen fertilizer, crop protection chemicals, and agricultural seeds. AFADA has recently extended its membership to other associations in agriculture, agroprocessing entrepreneurs, agricultural product marketing firms, and the national farmers' union. AFADA members with IFDC support have begun exporting vegetables to the European Union. IFDC promoted trade associations as a means of transferring technology to farmers; as a result AFADA was presented as a case study at a World Bank Extension Workshop. IFDC has supported crop modeling, model validation experiments, and computer simulation to provide information to AFADA members for their technology transfer activities. With assistance from Mississippi State University (MSU), IFDC has established a modern seed testing laboratory and a germplasm storage facility. The Center has also introduced a draft fertilizer law and regulations and begun work to establish a fertilizer and soil analytical laboratory.
- With funding from the International Fertilizer Industry Association (IFA), IFDC-Africa and its partners in the national agricultural research and extension systems of Togo, Benin, and Niger are implementing a project to strengthen linkages between farmers, fertilizer dealers, research and extension workers through appropriate policy reforms, market research and development activities. One hundred and twenty small-scale farmers, including 30 women, are actively involved in the evaluation of different sources of organic and inorganic plant nutrients. A farmer-managed credit system (Fertilizer Revolving Fund) has been

institutionalized in each of four target communities to provide credit in kind to farmers to fertilize approximately 0.5 ha of cropland. Eighty-five national research and extension workers and other agricultural development professionals in the target regions are being trained in various aspects of agricultural research and development. Field days have been organized in all four communities to allow non-project farmers in adjoining communities, input and output dealers, and policymakers to learn of the project activities.

- IFDC continued to assist Petroquimica de Venezuela S.A. (PEQUIVEN) in the design and implementation of its transition to a market-driven enterprise. The overall goal of this project has been to help the company retain its leading position in the marketplace and become competitive in a free market environment. PEQUIVEN's strengths that have been enhanced include a fully integrated fertilizer processing infrastructure; a capable and experienced staff; access to indigenous raw materials; a prime geographic location for domestic and regional markets; a sound financial position; a recognized name in the industry, both domestically and internationally; and an existing network of agents, dealers and distributors. Throughout the project, PEQUIVEN's overall fertilizer production capacity has increased from 60% to more than 85% of rated capacity. The production rates of the ammonia and urea units are nearing 100% capacity. Production costs have been significantly reduced, enabling the company to generate substantial profits despite holding domestic prices below international levels at the request of the Government of Venezuela.
- IFDC's fertilizer market information group produces reports on fertilizer marketing data for a worldwide audience. In addition, the group prepares a series of proprietary reports for members of The Fertilizer Institute. A few of the reports prepared by the group include the following: *Recent Fertilizer Project Announcements and Proposals; A Guide to Fertilizer Products for Traders; Worldwide Potash Capacity Listing by Plant; Worldwide Directory of Fertilizer Traders, Importers, and Organizations; Worldwide Urea Capacity Listing by Plant; Worldwide Ammonia Capacity Listing by Plant; North America Fertilizer Capacity; World Fertilizer Supply/Demand Situation; Fertilizer Price and Consumption Survey; Worldwide List of DAP Manufacturers and Traders; Worldwide Ammonium Nitrate and Calcium Ammonium Nitrate Capacity Listing by Plant; and The Basics of Zinc in Crop Production.*

Natural Resource and Environmental Management

- Soil nitrogen and phosphorus dynamics studies in pasture-based systems of Brazil were conducted on two long-term experiments in collaboration with the Centro de Energia Nuclear na Agricultura (CENA), the University of Sao Paulo, and Centro Nacional de Pesquisa de Agrobiologia-Empresa Brasileira de Pesquisa Agropecuaria (CNPAB-EMBRAPA). One experiment was located in the Amazon where tropical forest had been replaced by pastures, and the other study used the CENTURY model to assess a long-term experiment conducted in the Cerrados region.
- An IFDC scientist outposted to the Centro Internacional de Agricultura Tropical (CIAT)'s Tropical Lowlands Program coordinated research activities on sustainable crop rotation and ley farming systems for the acid-soil savannas. This experiment, which is a component of CIAT's research on nutrient cycling, dynamics of soil organic matter, soil physical health, and sustainability indicators, compares a range of agricultural production systems.
- The long-term study on the environmental impact of repeated application of cadmium-containing phosphate fertilizers showed that there was no consistent or significant increase in cadmium in plant tissues. As in the previous years, cadmium content in maize decreased with increase in plant biomass resulting from increased nutrient availability. Cadmium availability to plants was influenced by several soil factors.
- Research on indigenous phosphate rocks – Jhamarkotra rock (India) and Jiangxiang rock (China) – confirmed previous findings that low reactive phosphate rocks are not suitable for direct application even to acid soils. However, when these two phosphate rocks are modified through partial acidulation or compaction with soluble phosphate materials, their agronomic effectiveness is significantly increased.
- Two visiting scientists from Russia and Syria conducted phosphate research at Headquarters. The work of the Russian scientist, which was sponsored by the Cooperation in Applied Science and Technology (CAST) Program, funded by USAID, and administered by the National Research Council, focused on strategies for minimizing cadmium uptake from phosphate fertilizers by food crops. She also conducted

research on the agronomic effectiveness of three phosphate rocks that are indigenous to Russia and Kazakhstan. The Syrian scientist, sponsored by the Fulbright Scholar Program, concentrated on the agronomic effectiveness of directly applied phosphate rock and investigated methods such as the IFDC-developed Pi test for measuring available phosphorus in soil.

- With funding from the International Fund for Agricultural Development, IFDC-Africa, the African Centre for Fertilizer Development (Zimbabwe), and the Tropical Soil Biology and Fertility Program (Kenya) began in 1996 a 3-year project aimed at developing integrated soil improvement and nutrient management practices. The hypothesis of the project is that soil improvement leads to higher recovery of applied nutrients and thus to higher yields and/or products of better quality. The project is being conducted in West Africa and East/Southern Africa in areas where the population density is exceeding the carrying capacity and socioeconomic conditions are favorable.
- IFDC-Africa assisted Burkina Faso in establishing a Soil Fertility Management Unit (SFMU) within the Ministry of Agriculture to ensure that an adequate strategy is developed and implemented to improve the production base of soil. With funding assistance from the Directoraat Generaal voor International Samenwerking (DGIS), the SFMU will promote national and international awareness of the need to implement an integrated strategy for the restoration and maintenance of soil fertility. The Unit will develop integrated soil fertility restoration and maintenance strategies, plus action plans to improve soil fertility and promote sustainable agricultural production.
- The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is taking the lead in a Desert Margins Initiative to find solutions to the problems created by land degradation in the desert margins of Africa. IFDC is collaborating on this initiative with several national agricultural research systems (NARS), advanced research organizations (AROs), and other international agricultural research centers. This initiative focuses on arresting land degradation by promoting innovative technologies that integrate effective nutrient management strategies with improved soil and water conservation techniques that are ecologically sound, economically viable, and socially acceptable to farmers in the dryland areas of sub-Saharan Africa. The key goal of this initiative is to enhance the food security of poor rural populations and alleviate poverty by halting or reversing desertification.
- IFDC is also involved in the Soil, Water, and Nutrient Management Initiative, along with a number of other international organizations. The four consortia being developed under the initiative focus on combating nutrient depletion, managing acid soils, managing soil erosion, and optimizing soil/water use.
- The primary factor that impedes agricultural growth in Africa is continuous mining of soil nutrients. Until this problem is overcome any other efforts to raise crop yields will not change the current trend of declining per capita food production. Recognizing this, the World Bank has launched the Soil Fertility Initiative. To increase awareness of the importance of restoring soil fertility, an information packet outlining the Initiative was distributed at the World Food Summit. An international workshop to discuss the soil fertility issues and develop pilot projects is planned for early 1997 at IFDC-Africa in Lomé, Togo.
- IFDC performed basic research on the development of a slow-release floating fertilizer for use in ocean farming of commercial fish. Raw materials and products will be tested using a synthetic seawater prepared from salts used to prepare and maintain seawater aquariums.
- IFDC prepared tableted synthetic apatite samples to provide a phosphate source for hydroponic experiments aboard the National Aeronautics and Space Administration (NASA) Space Shuttle and for future use in space stations.
- IFDC staff completed economic and financial analyses of the potential costs of producing and distributing direct application phosphate rock from the Kodjari Deposit in Burkina Faso.
- Phosphate rock samples from Tunisia and Algeria were mineralogically and chemically characterized to determine their suitability for direct application. Work began on the characterization and the determination of the suitability of phosphate rock from Jordan for direct application.

Management Information Systems

- In collaboration with Instituto Nacional de Investigacion Agropecuaria and a nongovernmental organization, IFDC researchers calibrated and validated the CERES-Barley and CERES-Wheat models for barley- and wheat-growing regions in the South American Pampas of Uruguay and Argentina. Data on input use, pest incidence, and grain yields collected from more than 1,000 wheat fields over 5 years were used

to develop programs for natural resource planning at the farm level. Partially funded by the Rockefeller Foundation, the project is linking simulation models with a Geographic Information System (GIS) and an Automated Land Evaluation System (ALES) program.

- At the request of the International Food Policy Research Institute (IFPRI), IFDC prepared a paper entitled "The Role of Fertilizers in Sustaining Food Security and Protecting the Environment: Trends to 2020" for its 2020 Vision for Food, Agriculture, and the Environment initiative. The paper analyzed the need for fertilizers to meet the food requirements of more than 8 billion people in 2020 and to preserve the natural resource base for sustainable food production. It also identified various physical, institutional, and policy-related constraints to supplying and using the needed fertilizers in an environmentally sound manner.
- In collaboration with the Soil Management Support Services of the U.S. Department of Agriculture (USDA) and the Land Resources Institute of Albania, IFDC conducted a survey of Albania's soil resources. The end product of the survey was a soils map to assist policymakers, farmers, and other decisionmakers in the design and implementation of sustainable soil management and conservation practices. Accurate soils maps are needed to implement conservation measures successfully and to manage more effectively valley bottom soils so that agricultural pressures on marginal sloping land are reduced.
- During 1995/96 the Decision Support System for Agrotechnology Transfer (DSSAT) software package was modified to accommodate increasing application of crop modeling through spatial analyses in GIS. All of the crop models can be run in one of three modes: single-season analysis, seasonal analysis, and sequential analysis. Cooperation between IFDC's crop modelers and Dutch modelers at Wageningen Agricultural University resulted in the further standardization of model data input/output structures and the development of geostatistical and spatial analysis standards for model input files for precision farming and GIS applications.
- In collaboration with a scientist from CIAT, simple dynamic land use models were developed to investigate changes in land use in a region over time and isolate the primary factors that cause these changes. Two simple models, which were built and tested, involve lookup tables and sets of decision rules that result in particular patterns of land use within a region.

Human Capacity Building

- At the request of the Ministry of Agriculture, Livestock Development and Marketing, Government of Kenya, IFDC conducted two in-country training programs on fertilizer marketing and soil fertility management in that country during 1996. Funded by the World Bank, the programs attracted entrepreneurs and officials of the Ministry of Agriculture, various cooperatives, fertilizer companies, and nongovernmental organizations.
- IFDC conducted a fertilizer study tour for managers from FERQUIMEX/FERTIMINA of Mexico at IFDC and various locations throughout the United States. To assist these fertilizer companies as they make the transition toward privatization, IFDC conducted the study tour to allow the participants the opportunity to enhance their knowledge of new technologies and issues confronting the fertilizer industry.
- In cosponsorship with the Fertiliser Association of India and Asosiasi Produsen Pupuk Indonesia, IFDC conducted an International Study Tour on Fertilizer Distribution and Handling. Field trips in India, Singapore, and Indonesia gave the participants a firsthand view of effective physical distribution activities. By enhancing their knowledge of the requirements for planning, operating, and developing physical distribution systems, these senior managers will be better able to ensure timely availability of fertilizer to farmers.
- An International Training Program and Study Tour on Fertilizer Marketing Challenges was conducted at Headquarters and various other locations in the United States. Four technologies were discussed throughout the program: information technology, conservation tillage, biotechnology, and precision agriculture.
- IFDC's crop modelers participated as instructors in the University of Georgia's Training Program on Computer Simulation of Crop Growth and Management Responses. During the program workshop participants learned how a comprehensive simulation model of crop growth and development and water and nutrient dynamics is constructed and how it can be applied to real world problems.
- Two IFDC Production Services staff members traveled to Egypt and trained Egyptian Fertilizer Development Center staff in pilot-plant operations. Three plant configurations were used to produce eight different granular NPK products.

Resumen Ejecutivo

La restauración y el mejoramiento de la fertilidad de suelos en los países con bajos ingresos y escasez de alimentos, especialmente aquellos del sub-Sahara africano, son componentes claves en el desarrollo de la seguridad global de alimentos, de sistemas de agricultura sustentable y por lo tanto, del alivio de pobreza. En reconocimiento a la importancia de la fertilidad de suelos, el tema de este informe anual es "Creando Suelos Fértiles para un Mundo con Seguridad Alimenticia."

Los siguientes párrafos resumen las actividades del IFDC en 1996 en las áreas de desarrollo de mercados, manejo de recursos naturales y medio ambiente, sistemas de manejo de información y desarrollo de resursos humanos.

Desarrollo de Mercado

- El Proyecto de Desarrollo de Tecnología de la Industria Basada en la Agricultura (ATDP) con duración de 30 meses está siendo implementado por el Gobierno de Bangladesh, la Agencia Estadounidense para el Desarrollo Internacional (USAID) y un consorcio compuesto por el IFDC – como contratista principal, la Winrock International y la Ronco Consulting Corporation. La meta del proyecto consiste en aumentar el empleo productivo en la agricultura y empresas afines a través de la creación de mercados competitivos para los insumos, productos y tecnologías de la agricultura y negocios agrícolas. El proyecto está promoviendo reformas en todas las áreas de políticas de Bangladesh – políticas industriales y agrícolas, fiscales y comerciales, de inversión extranjera, y legales y reglamentarias. Se están iniciando empresas de negocios agrícolas, y algunas empresas existentes se están ampliando con una financiación de más de US $50 millones de un fondo de crédito para negocios agrícolas. El avance tecnológico en la agroindustria está siendo estimulado a través de la asistencia técnica, el desarrollo de recursos humanos y los contratos de negocios.
- En colaboración con la Winrock International, el IFDC contribuyó al proyecto de la USAID de Apoyo para la Reestructuración Agrícola en Albania (SARA), el cual promueve la seguridad alimenticia a través de un programa de base amplia orientado hacia el crecimiento económico del mercado. El IFDC ha desarrollado con el Directorado de Estadística del Ministerio de Agricultura y Alimentos (MOAF), una encuesta estadística y un análisis de capacidad comprensivos. El Centro le ha proporcionado a los empresarios albaneses, tres módulos de negocios agrícolas – Sistemas de Productos Agrícolas, Planeación y Desarrollo de Negocios, y Promoción del País. Estos módulos han sido presentados a más de 1,500 empresarios y serán institucionalizados en la unidad de Publicaciones Especiales de la Asociación de Distribuidores de Fertilizante y Negocios Agrícolas (AFADA). Se le presentará un video sobre la Promoción del País a inversionistas potenciales en los Estados Unidos, la Unión Europea, los Países Balcanes y a los mercados del medio oriente para atraer inversiones y comercio.
- Como parte de otro proyecto de la USAID titulado "Sosteniendo el Subsector Reestructurado de Fertilizantes en Albania," el IFDC desarrolló estrategias de comercialización para fertilizantes, productos químicos para la protección de cultivos, y semilla; estos mercados de insumos agrícolas han sido privatizados por los miembros de la asociación de comercio AFADA, la cual es patrocinada por el IFDC. Con la asistencia del IFDC, los miembros de AFADA pueden ahora importar y comerciar todo el fertilizante nitrogenado de Albania además de productos químicos para la protección de cultivos y semillas agrícolas. La AFADA recientemente extendió su membresía a otras asociaciones agrícolas, empresarios de agriprocesos, compañías de mercadeo de productos agrícolas y la unión nacional de agricultores. Los miembros de la AFADA han comenzado a exportar vegetales a la Unión Europea con la ayuda del IFDC. El IFDC promovió las asociaciones de comercio como un medio para transferirle tecnología a los agricultores; como resultado se presentó la AFADA como un caso de estudio en una Reunión de Trabajo de Extensión del Banco Mundial. El IFDC ha promovido el modelaje de cultivos, experimentos de validación de modelos y simulaciones en computador para suministrarle información a los miembros de la AFADA para sus

actividades de transferencia de tecnología. A través de la asistencia de la Universidad del Estado de Mississippi (MSU), el IFDC ha establecido un moderno laboratorio para probar semillas e instalaciones de almacenaje para gérmen plasma. El Centro también ha presentado un borrador de leyes y reglamentaciones sobre fertilizantes y ha comenzado trabajos para establecer un laboratorio de fertilizantes y análisis de suelos.

- Bajo el patrocinio de la Asociación Internacional de la Industria de Fertilizantes (IFA), el IFDC-Africa y sus socios en los sistemas nacionales de investigación y de extensión agrícola de Togo, Benín, y el Níger, se está implementando un proyecto para reforzar los enlaces entre los agricultores, distribuidores de fertilizantes, investigadores y los trabajadores de extensión a través de las reformas de políticas, investigación de mercados y actividades de desarrollo apropiados. Ciento veinte agricultores a pequeña escala, incluyendo a 30 señoras, se encuentran activamente trabajando en la evaluación de diferentes fuentes de nutrientes de plantas orgánicos e inorgánicos. Se ha institucionalizado un sistema de crédito manejado por los agricultores (Fondo Rotatorio de Fertilizantes) en cada una de cuatro comunidades el cual suministrará crédito en especie a los agricultores para que fertilicen aproximadamente 0.5 ha en terrenos de cultivos. Se están entrenando ochenta y cinco investigadores y trabajadores nacionales de extensión y otros profesionales de desarrollo agrícola en las regiones designadas en los diferentes aspectos de investigación y desarrollo agrícola. Se han organizado visitas de campo en las cuatro comunidades para permitirle participación a los agricultores que no forman parte del proyecto pertenecientes a comunidades aledañas, a distribuidores de insumos y productos, y a los forjadores de políticas para que aumenten conocimientos sobre las actividades del proyecto.
- El IFDC continuó su asistencia a Petroquímica de Venezuela S.A. (PEQUIVEN) en el diseño y la implementación de su transición a una empresa competitiva. La meta global de este proyecto ha sido la de ayudar a la empresa a retener su posición de líder en el mercado y ser competitiva en un ambiente de mercado libre. Se han mejorado las fortalezas de PEQUIVEN incluyendo una infraestructura de proceso de fertilizante totalmente integrada; personal capacitado y con experiencia; acceso a materias primas locales; localidad geográficamente favorable para mercados domésticos y regionales; una condición financiera sólida; nombre reconocido en la industria tanto doméstica como internacional y una red existente de agentes, detallistas y distribuidores. A través del proyecto, la capacidad de producción global de fertilizantes de PEQUIVEN ha aumentado del 60% a más del 85% de su capacidad instalada. Las tasas de producción en las unidades de amoníaco y urea se acercan al 100% de capacidad. Los costos de producción se han disminuído considerablemente, permitiéndole así a la empresa generar ganancias sustanciales a pesar de mantener los precios por debajo de los niveles internacionales a petición del Gobierno de Venezuela.
- El grupo de información de mercado de fertilizantes del IFDC genera informes sobre datos de mercadeo de fertilizante para una audiencia mundial. Además, el grupo produce una serie de informes privados para los miembros de El Instituto de Fertilizantes (TFI). Algunos de los informes preparados por el grupo incluyen los siguientes: *Anuncios y Propuestas Recientes sobre Proyectos de Fertilizantes; Una Guía de Productos Fertilizantes para Comerciantes; Listado Mundial de Capacidad de Potasio por Planta; Directorio Mundial de Comerciantes, Importadores y Organizaciones de Fertilizantes; Listado Mundial de Capacidad de Urea por Planta; Listado Mundial de Capacidad de Amoníaco por Planta; Capacidad de Fertilizantes de Norteamérica; Situación Mundial de Oferta/Demanda de Fertilizantes; Encuesta sobre Precio y Consumo de Fertilizantes; Listado Mundial de Manufacturadores y Comerciantes de DAP; Listado Mundial de Capacidad de Nitrato de Amónio y Nitrato de Amónio Cálcico por Planta; y Lo Básico sobre el Zinc en la Producción Agrícola.*

Manejo de Recursos Naturales y el Medio Ambiente

- Se llevaron a cabo estudios sobre la dinámica del nitrógeno y fósforo de suelos en sistemas de pastos en el Brasil durante dos experimentos a largo plazo en colaboración con el Centro de Energia Nuclear na Agricultura (CENA), la Universidad de Sao Paulo y el Centro Nacional de Pesquisa de Agrobiologia-Empresa Brasileira de Pesquisa Agropecuaria (CNPAB-EMBRAPA). Se localizó un experimento en el

Amazonas donde la selva tropical había sido reemplazada por pastos, y el otro estudio utilizó el modelo CENTURY para evaluar un experimento a largo plazo llevado a cabo en la región de Cerrados.

- Un científico enviado por el IFDC al Programa de Tierras Bajas Tropicales del Centro Internacional de Agricultura Tropical (CIAT) coordinó varias actividades de investigación sobre la rotación sustentable de cultivos y ciertos sistemas claves de agricultura para las sabanas de suelo ácido. Este experimento, el cual es un componente de las investigaciones del CIAT sobre el ciclaje de nutrientes, la dinámica de la materia orgánica de suelos, la salud física de suelos e indicadores de sustentabilidad, compara una gama de sistemas de producción agrícola.
- El estudio a largo plazo sobre el impacto ambiental de la aplicación repetida de los fertilizantes fosfatados con cadmio demostró que no hubo ningún aumento consistente o significativo de cadmio en los tejidos de las plantas. Como en años anteriores, el contenido de cadmio en el maíz disminuyó con el aumento de la biomasa como resultado del aumento en la disponibilidad de nutrientes. La disponibilidad de cadmio para las plantas fue influenciada por varios factores de los suelos.
- Las investigaciones llevadas a cabo sobre el uso de roca fosfórica confirma los resultados obtenidos anteriormente de que algunas rocas fosfóricas locales de baja reactividad (la roca Jhamarkotra del Estado de Rhajastan, India y la roca Jiangxiang de la Provincia Hubei, China) no son adecuadas para la aplicación directa aún a suelos ácidos. Sin embargo, cuando estas dos rocas fosfóricas se modifican a través de la acidulación parcial o son compatadas con materiales de fosfato soluble, su efectividad agronómica se aumenta significativamente.
- Dos científicas visitantes de Rusia y Siria llevaron a cabo investigaciones sobre fosfatos en la Sede. El trabajo de la científica rusa, el cual fue patrocinado por el Programa de Cooperación de Ciencia y Tecnología Aplicadas (CAST), financiado por la USAID y administrado por el Consejo Nacional de Investigación (NRC), hizo enfoque sobre las estrategias para minimizar la absorción de cadmio a partir de los fertilizantes fosfatados por las cultivos alimenticias. La científica rusa además condujo investigaciones acerca de la efectividad agronómica de tres rocas fosfóricas que se encuentran localmente en Rusia y Khazakhstan. La científica siria, quien fue patrocinada por el Fulbright Scholar Program, se concentró sobre la efectividad de la roca fosfórica aplicada directamente e investigó varios métodos tales como el análisis del Pi desarrollado por el IFDC para medir el fósforo disponible del suelo.
- Con el financiamiento del Fondo Internacional para el Desarrollo Agrícola (IFAD), IFDC-Africa, el Centro Africano para el Desarrollo de Fertilizantes (Zimbabwe) y el Programa sobre Biología y Fertilidad de Suelos Tropicales se comenzó en 1996 un proyecto de tres años enfocado hacia el desarrollo de prácticas integradas de mejoramiento de los suelos y de manejos de nutrientes. La hipótesis del proyecto es que el mejoramiento del suelo conduce a una mayor asimilación de nutrientes aplicados y por lo tanto a mayores rendimientos o a productos de mayor calidad. El proyecto se está llevando a cabo en el Africa Occidental y en las áreas del Africa Suroriental donde la densidad de población no se puede mantener, pero donde las condiciones socioeconómicas son favorables.
- El IFDC-Africa prestó asistencia a Burkina Faso para establecer una Unidad de Manejo de Fertilidad de Suelos (SFMU) en el Ministerio de Agricultura para asegurar que se desarrolle e implemente una estrategia adecuada para mejorar la base de producción del suelo. Con el apoyo financiero del Directoraat Generaal voor International Samenwerking (DGIS), la SFMU promoverá la concientización nacional e internacional sobre la necesidad de implementar una estrategia integrada para la restauración y mantenimiento de la fertilidad de suelos. La Unidad desarrollará varias estrategias integradas de restauración y mantenimiento de fertilidad de suelos, además de planes de acción para mejorar la fertilidad de suelos y promover la producción agrícola sustentable.
- El Instituto Internacional de Investigación de Cultivos para los Trópicos Semiáridos (ICRISAT) está sirviendo de líder de la Iniciativa de Márgenes del Desierto para encontrar soluciones a los problemas creados por la degradación de tierras en los márgenes de los desiertos del Africa. El IFDC está colaborando en esta iniciativa junto con varios sistemas nacionales de investigación agrícola (NARS), organizaciones de investigación avanzada (AROs), y otros centros internacionales de investigación agrícola. Esta iniciativa hace enfoque en detener la degradación del suelo al promover tecnologías innovadoras que integren las

estrategias en el manejo efectivo de nutrientes con las técnicas de mejoramiento de suelos y conservación de agua que sean ecológicamente favorables, económicamente viables y socialmente aceptables para los agricultores en las tierras de secana en el sub-Sahara del Africa. La meta clave de esta iniciativa es mejorar la seguridad de alimentos en las poblaciones rurales de bajos recursos y aliviar la pobreza al detener o reversar la desertificación.

- El IFDC también está involucrado junto con otras organizaciones internacionales en una iniciativa de manejo de suelos, agua y nutrientes. Los cuatro consorcios desarrollándose tienen el enfoque de combatir la pérdida de nutrientes, manejar los suelos ácidos, manejar la erosión del suelo, y optimizar el uso de suelos y agua.
- El principal factor que impide el crecimiento agrícola en el Africa es el contínuo minar de sus nutrientes del suelo. Mientras este problema no se haya superado, otros esfuerzos para elevar los rendimientos de cultivos no cambiarán la tendencia actual de tener una producción descendiente de alimentos per cápita. Reconociendo ésto, el Banco Mundial ha lanzado la Iniciativa para la Fertilidad de Suelos. Con el fín de aumentar la atención sobre la importancia de restaurar la fertilidad de suelos, se distribuyó un paquete de información sobre la Iniciativa en la Reunión Cumbre Mundial sobre Alimentos. Se ha planeado una reunión internacional de trabajo para discutir temas de fertilidad de suelos y desarrollar proyectos piloto a comienzos de 1997 en el IFDC-Africa en Lomé, Togo.
- El IFDC llevó a cabo investigaciones básicas sobre el desarrollo de un fertilizante flotante de asimilación lenta para uso en el aumento de peces comerciales en el océano. Las materias primas y los productos serán probados utilizando agua de mar sintética preparada a partir de sales que son utilizadas para preparar y mantener acuarios de agua de mar.
- El IFDC preparó tabletas de apatita sintética para proveer una fuente de fosfato en experimentos dentro de las naves del espacio de la Administración Nacional de la Aeronáutica y el Espacio (NASA) y para su uso futuro en las estaciones espaciales.
- El personal del IFDC completó los análisis económicos y financieros sobre los costos potenciales para producir y distribuír la roca fosfórica de aplicación directa del Depósito de Kodjari en Burkina Faso.
- Se llevó a cabo la caracterización mineral y química de las muestras de roca fosfórica de Tunisia y Argelia para determinar si son apropiadas para su aplicación directa. Se comenzó a trabajar en la caracterización de la roca fosfórica de Jordania para determinar si ésta es apropiada para la aplicación directa.

Sistemas de Manejo de Información

- En colaboración con el Instituto Nacional de Investigación Agropecuaria y una organización no gubernamental, los investigadores del IFDC calibraron y validaron los modelos de CERES-Cebada y CERES-Trigo para las regiones de cultivos de cebada y trigo en las pampas suramericanas de Uruguay y Argentina. Se utilizaron datos de 5 años sobre el uso de insumos, incidencia de pestes y rendimientos de granos provenientes de más de 1,000 campos de trigo para desarrollar planes sobre recursos naturales a nivel de granja. El proyecto está parcialmente financiado por la Fundación Rockefeller y está enlazando modelos de simulación con un Sistema de Información Geográfica (GIS) y un programa de Sistema Automatizado de Evaluación de Tierras (ALES).
- A petición del Instituto Internacional para la Investigación de Políticas Alimenticias (IFPRI), el IFDC preparó un estudio titulado "El Papel que Juegan los Fertilizantes en Sostener la Seguridad Alimenticia y Proteger el Medio Ambiente: Tendencias hacia 2020" para su iniciativa de Visión 2020 para Alimentos, Agricultura y el Medio Ambiente. El estudio analizó la necesidad del uso de los fertilizantes para lograr las necesidades alimenticias de las más de 8 mil millones de personas que habrá en el año 2020 y para preservar la base de recursos naturales para la producción sustentable de alimentos. El estudio también identificó varios impedimentos físicos, institucionales y relacionados a políticas que impiden el suministro o el uso de los fertilizantes en una forma ambientalmente adecuada.
- En colaboración con los Servicios de Apoyo para el Manejo de Suelos del Departamento de Agicultura de los Estados Unidos (USDA) y el Instituto de Recursos de Tierras de Albania, el IFDC condujo una encuesta sobre los recursos de suelos en Albania. El resultado de la encuesta fue un mapa de suelos para ayudar a los forjadores de políticas, agricultores y otras personas que toman decisiones en el diseño e implementación

de manejo sustentable de suelos y de prácticas de conservación. Los mapas precisos de suelos son necesarios para realizar las medidas de conservación en forma exitosa y utilizar más efectivamente los suelos bajos de los valles de manera que se reduzcan las presiones agrícolas sobre las tierras en declive y marginales.

- Durante 1995/96 se modificó el programa de computador Sistema de Apoyo para la Toma de Decisiones en la Transferencia de Agrotecnología para incluir el modelaje de cultivos a través de los análisis espaciales en el GIS. Todos los modelos de cultivos pueden correrse en una de tres modalidades: análisis de una sola estación, análisis estacional, y análisis secuencial. La cooperación entre los modeladores de cultivos del IFDC y los modeladores holandeses en la Universidad Agrícola de Wageningen resultó en una mayor estandarización en las estructuras de datos de suministro y resultados y en el desarrollo de estándares geoestadísticos y de análisis espaciales para los archivos de suministro de datos en los modelos de agricultura a precisión y en aplicaciones del GIS.
- En colaboración con un científico del CIAT, se desarrollaron modelos sencillos y dinámicos sobre el uso de tierras para investigar los cambios en la utilización de tierras de una región por un espacio de tiempo y así poder aislar los factores primarios que causan estos cambios. Se construyeron y probaron dos modelos sencillos los cuales incluyen tablas para buscar datos y varios juegos de reglas para la toma de decisiones que resultan en patrones de uso de tierras dentro de una región.

Desarrollo de Capacitación Humana

- A petición del Ministerio de Agricultura, Desarrollo de Ganado y Mercadeo del Gobierno de Kenya, el IFDC llevó a cabo en 1996 dos programas de entrenamiento en el país sobre comercialización de fertilizantes y manejo de fertilidad de suelos. Los programas fueron financiados por el Banco Mundial y atrajeron a comerciantes y funcionarios del Ministerio de Agricultura, de varias cooperativas, de compañías de fertilizantes y de organizaciones no gubernamentales.
- El IFDC llevó a cabo una gira de estudio sobre fertilizantes para administradores de FERQUIMEX/ FERTIMINA de México en el IFDC y otras localidades a través de los Estados Unidos. Con el fin de ayudar a estas empresas de fertilizantes a lograr su transición hacia la privatización, el IFDC condujo la gira de estudio para proporcionarle a los participantes la oportunidad de aumentar sus conocimientos sobre nuevas tecnologías y sobre los temas que confronta la industria fertilizante.
- En copatrocinio con la Asociación de Fertilizantes de la India y la Asosiasi Produsen Pupuk Indonesia, el IFDC llevó a cabo una Gira Internacional de Estudio sobre la Distribución y el Manejo de Fertilizantes. Se hicieron visitas de campo a la India, Singapur e Indonesia para darle a los participantes una experiencia de primera mano sobre las actividades efectivas de distribución física. Al aumentar sus conocimientos sobre los requerimientos para planificar, operar y desarrollar sistemas de distribución física, estos gerentes de alto mando podrán asegurarle la disponibilidad oportuna de los fertilizantes a los agricultores.
- Se llevó a cabo un Programa Internacional de Entrenamiento y Gira de Estudio sobre los Retos del Mercadeo de Fertilizantes en la Sede del IFDC y en otras localidades en los Estados Unidos. Se trataron cuatro tecnologías a través del programa: tecnología de información, arado para la conservación, biotecnología y agricultura a precisión.
- Los modeladores de cultivos participaron como instructores en el Programa de Entrenamiento de la Universidad de Georgia sobre la Simulación de Crecimiento de Cultivos y Respuestas de Manejo en Computador. Durante el programa los participantes en este taller de trabajo aprendieron cómo se construye un modelo comprensivo de simulación de crecimiento de cultivos y de dinámica de agua y nutrientes, y cómo éste puede ser aplicado a problemas reales en el mundo.
- Dos miembros del personal de Servicios de Producción del IFDC viajaron a Egipto y entrenaron al personal del Centro Egipcio para el Desarrollo de Fertilizantes en las operaciones de su planta piloto. Se utilizaron tres configuraciones de planta para producir ocho diferentes productos de NPK granulares.

Résumé Analytique

La restauration et la maintenance de la fertilité des sols dans les pays à faible revenu et à déficit alimentaire, particulièrement ceux de l'Afrique sub-saharienne, sont un élément clé de la sécurité alimentaire, de la durabilité des systèmes agricoles et de l'allègement de la pauvreté dans le monde. Conscient de cette réalité, le Centre International pour la Gestion de la Fertilité des Sols (IFDC) a basé le présent rapport annuel sur le thème: "Développer des sols fertiles pour la sécurité alimentaire dans le monde."

Ce rapport résume les activités menées par l'IFDC en 1996 dans les domaines suivants: le développement de marché, la gestion des ressources naturelles et de l'environnement, la gestion des systèmes d'information, et le développement des ressources humaines.

Développement de marché

- Le Projet de développement de la technologie et de l'industrie basées sur l'agriculture – Agro-Based Industry and Technology Development Project – (ATDP) est mis en oeuvre par le Gouvernement du Bangladesh, l'Agence américaine pour le développement international (USAID) et un consortium composé de l'IFDC – comme premier contractant - Winrock International et Ronco Consulting Corporation. Ce projet a pour objectif d'accroître les emplois productifs dans l'agriculture et les entreprises connexes par la création de marchés compétitifs pour les intrants, les techniques et les produits agricoles et agro-industriels. Il encourage également des réformes de politique dans tous les domaines du développement au Bangladesh – agriculture et industrie, commerce et fiscalité, investissement à l'étranger, législation et règlementation. A travers ce projet, l'IFDC aide au développement du secteur agro-industriel de ce pays. De nouvelles entreprises agro-industrielles voient le jour tandis que celles déjà établies sont renforcées grâce à un financement provenant d'un fonds de crédit agricole d'un montant de plus 50 millions de dollars US. Les progrès technologiques en agro-industrie sont stimulés par le biais de l'assistance technique, du développement des ressources humaines et de contrats commerciaux.
- En collaboration avec Winrock International, l'IFDC a collaboré au Projet d'appui pour la restructuration de l'agriculture en Albanie - Support for Agricultural Restructuring in Albania – (SARA) mis en oeuvre par l'USAID. Ce projet appuie les efforts visant au renforcement de la sécurité alimentaire, par un vaste programme de croissance économique axé sur le marché. L'IFDC a développé au sein du Bureau des statistiques du ministère de l'Agriculture et de l'Alimentation une capacité polyvalente de recherche et d'analyse statistique. Dans ce contexte, trois modules ont été mis à la disposition des entrepreneurs albanais: Systèmes de commerce des denrées agricoles, Planification et mise en place de l'entreprise et Promotion du Pays. Ces modules ont été présentés à plus de 1 500 entrepreneurs en agro-industrie et seront institutionnalisés à travers l'unité des Publications spéciales de l'Albanian Fertilizer and Agribusiness Dealers'Association (AFADA). Une production video illustrant le module Promotion du pays sera présentée à des investisseurs potentiels aux Etats-Unis, en Union européenne, dans les pays balkans et les marchés du Moyen-Orient, pour attirer des investissements et susciter des échanges.
- Dans le cadre d'un autre projet de l'USAID intitulé "Appuyer le sous-secteur restructuré des engrais en Albanie," l'IFDC a développé des stratégies de commercialisation pour les engrais, les semences et les produits phytosanitaires. Le marché de ces intrants agricoles a été privatisé par les membres de l'AFADA. Avec l'aide de l'IFDC, ces derniers importent et commercialisent actuellement tous les engrais azotés, les semences et les produits phytosanitaires utilisés en Albanie. L'AFADA s'est récemment ouverte à d'autres partenaires en agriculture, des entrepreneurs en agro-industrie, des sociétés de commercialisation de produits agricoles et des syndicats nationaux d'agriculteurs. Toujours avec l'aide de l'IFDC, les membres de l'AFADA se sont lancés dans les exportations de légumes vers les pays de l'Union européenne. L'IFDC se sert de la promotion de cette association commerciale comme un moyen d'assurer le tranfert de techniques aux agriculteurs. C'est ainsi que l'expérience de l'AFADA a été présentée comme une étude de

cas, à l'atelier sur la vulgarisation organisé par la Banque mondiale. L'IFDC a contribué à des expériences de modélisation de cultures, de validation de modèles et de simulation sur ordinateur visant à fournir aux membres de l'AFADA des informations utiles pour les activités de tranfert de technologie. De plus, avec l'aide de l'Université d'Etat du Mississippi, l'IFDC a mis en place un laboratoire moderne de certification des semences et des installations de stockage de germoplasmes, Le Centre a également introduit un projet de législation et de règlementation des engrais et a entrepris des travaux en vue de l'installation d'un laboratoire d'analyse des sols et des engrais.

- Avec un financement de l'International Fertilizer Industry Association, (IFA), l'IFDC-Afrique et ses partenaires des systèmes nationaux de recherche et de vulgarisation du Togo, du Bénin et du Niger mettent en oeuvre un projet qui vise à renforcer la collaboration entre les agriculteurs, les chercheurs, les vulgarisateurs et les distributeurs d'engrais par des réformes de politique et des activités de recherche et de développement de marché. Un total de120 petits agriculteurs dont 30 femmes participent activement à l'évaluation de différentes sources d'éléments nutritifs organiques et inorganiques. Un système de crédit géré par les agriculteurs (Fonds de roulement pour les engrais) a été institué dans chacun des quatre villages cibles pour assurer aux agriculteurs des crédits en nature leur permettant de fertiliser environ 0,5 ha de terre. Quatre-vingt-cinq chercheurs, vulgarisateurs et autres professionnels du développement agricole des zones cibles reçoivent actuellement une formation dans divers domaines de la recherche et du développement agricoles. Des journées agricoles ont été organisées dans les quatre villages pour permettre à d'autres agriculteurs des localités avoisinantes, des distributeurs d'engrais et des décideurs nationaux de s'informer des activités du projet.
- L'IFDC continue d'aider Petroquimica de Venezuela S. A. (PEQUIVEN) à organiser son passage à l'état d'entreprise axée sur le marché. L'objectif global de ce projet est de permettre à la compagnie de maintenir sa position prédominante sur le marché et de devenir compétitive dans un environnement de libre échange. Grâce à cet appui, PEQUIVEN a pu renforcer ses atouts qui sont : une infrastructure de transformation complètement intégrée; un personnel compétent et expérimenté; l'accès à des matières premières locales; un emplacement géographique de choix pour les marchés intérieurs et internationaux; une position financière confortable, un nom reconnu dans l'industrie tant au plan intérieur qu'international; et un réseau établi d'agents, de négociants et de distributeurs. Tout au long du projet, la capacité globale de production d'engrais de PEQUIVEN a nettement augmenté, passant de 60 % à 85 % de la capacité évaluée. Les taux de production des unités d'ammoniac et d'urée approchent 100 % de la capacité. Les coûts de production ont été considérablement réduits, ce qui a permis à la compagnie de générer des profits substantiels malgré le maintien des prix en dessous des niveaux internationaux, à la demande du gouvernement vénézuélien.
- Le Groupe d'information sur le marché des engrais de l'IFDC produit un ensemble de rapports sur la commercialisation des engrais qui sont distribués à travers le monde entier. De plus, le groupe prépare une série de rapports spécialisés pour des membres du Fertilizer Institute, dont les suivants: *Recent Fertilizer Project Announcements and Proposals*; *A Guide to Fertilizer Products for Traders, Importers and Organizations*; *Worldwide Urea Capacity Listing by Plant*; *Worldwide Ammonia Capacity Listing by Plant*; *North America Fertilizer Capacity*; *World Fertilizer Supply/Demand Situation*; *Fertilizer Price and Consumption Survey*; *Worldwide List of DAP Manufacturers and Traders*; *Worldwide Ammonium Nitrate and Calcium Ammonium Nitrate Capacity Listing by Plant*; *et The Basics of Zinc in Crop Production.*

Ressources naturelles et gestion de l'environnement

- Des études sur l'azote du sol et la dynamique du phosphore dans les systèmes pastoraux du Brésil ont été réalisées dans le cadre de deux essais à long terme, en collaboration avec le Centro de Energia Nuclear na Agricultura (CENA), l'Université de Sao Paulo et le Centro Nacional de Pesquisa de Agrobiologia-Empresa Brasileira de Pesquisa Agropecuaria (CNPAB-EMBRAPA). Un des essais était situé en Amazonie où la forêt tropicale est remplacée par des pâturages tandis que l'autre étude utilisait le modèle Century pour évaluer une expérience à long terme conduite dans la région des Cerrados.
- Un scientifique de l'IFDC a été détaché auprès du Centre International d'Agriculture Tropicale (CIAT), dans le cadre du Programme sur les bas-fonds des zones tropicales. Il est chargé de la coordination des

activités relatives aux systèmes durables de rotation des cultures et d'assolement avec pâtures temporaires pour les savanes à sol acide. Cette expérience qui est une composante de la recherche menée par CIAT sur le recyclage des éléments nutritifs, la dynamique de la matière organique du sol, la santé physique des sols et les indicateurs de durabilité, permet de comparer divers systèmes de production agricole.

- Une expérimentation de longue durée sur l'impact environnemental de l'application répétée d'engrais phosphatés contenant du cadmium a montré qu'il n'y avait pas d'accroissement significatif de la teneur en cadmium dans les tissus végétaux. Comme cela avait été observé au cours des années précédentes, la teneur en cadmium du maïs a plutôt diminué avec l'augmentation de la biomasse végétale résultant de la disponibilté accrue en éléments nutritifs. La disponibilité du cadmium pour les plantes est influencée par divers facteurs du sol.
- Les recherches sur les phosphates naturels de Jhamarkotra (Inde) et de Jiangxiang (Chine) ont confirmé le fait que les phosphates naturels faiblement réactifs ne sont pas efficaces en application directe, même sur les sols acides. Cependant, lorsque ces deux types de phosphate sont enrichis par une acidification partielle ou par le compactage avec des matériaux phosphatés solubles, leur efficacité agronomique augmente considérablement.
- Deux scientifiques, une Russe et une Syrienne, effectuent des recherches sur le phosphate au siège de l'IFDC. Les recherches de la Russe sont financées par l'USAID dans le cadre du programme de Cooperation in Applied Science and Technology (CAST) et dirigée par le National Research Council. Elles portent sur les stratégies permettant de minimiser l'absorption par les cultures vivrières du cadmium contenu dans les engrais phosphatés et sur l'efficacité agronomique de trois différents phosphates de la Russie et du Kazakhstan. Les travaux de la Syrienne sont financés par le Fulbright Scholar Program et sont centrés sur l'efficacité agronomique du phosphate appliqué directement. Ils touchent également aux méthodes de mesurage du phosphore disponible dans le sol, telles que celle de Pi mise au point par l'IFDC.
- Avec le financement du Fonds International de Développement Agricole, l'IFDC-Afrique, le Centre Africain pour le Développement des Engrais (Zimbabwe) et le Tropical Soil Biology and Fertility Program (Kenya) ont initié, en 1996, un projet triennal visant à développer des pratiques de gestion intégrée des éléments nutritifs et d'amélioration de la fertilité des sols. Ce projet est basé sur l'hypothèse selon laquelle l'amélioration des sols permettrait une meilleure récupération des éléments nutritifs appliqués, par conséquent, d'obtenir des rendements plus importants et des produits de meilleure qualité. Sa mise en oeuvre s'effectue en Afrique de l'Ouest, de l'Est et du Sud, dans des régions où la densité démographique dépasse la capacité de charge et où les conditions socio-économiques sont favorables.
- L'IFDC-Afrique a aidé le Burkina Faso à mettre en place une Unité de Gestion de la Fertilité des Sols (UGFS) au sein du ministère de l'Agriculture. Cette initiative qui bénéficie de l'appui financier du Directoraat Generaal voor International Samenwerking vise à faciliter l'élaboration et la mise en oeuvre de stratégies appropriées pour l'amélioration de la base de production qui est le sol. L'UGFS a pour objectif de susciter, au niveau national et international, une prise de conscience de la nécessité de stratégies intégrées pour restaurer et maintenir le capital de fertilité des sols. L'unité devra formuler des stratégies et des plans d'action pour l'amélioration de la fertilité des sols et la promotion de l'agriculture durable au Burkina Faso.
- L'Institut International de Recherche sur les Cultures des Zones Tropicales Semi-Arides (ICRISAT) dirige l'Action pour les zones limitrophes du désert qui vise à trouver des solutions aux problèmes qu'engendre la dégradation des sols dans cette partie de l'Afrique. L'IFDC participe à cette action en collaboration avec plusieurs systèmes nationaux de recherche agricole, des organisations de recherche avancée et un certain nombre de centres internationaux de recherche agricole. Cette action est axée sur l'arrêt de la dégradation des sols par la promotion de technologies innovatrices, qui intègrent des stratégies efficaces de gestion des éléments nutritifs et des pratiques améliorées de conservation des sols et de l'eau dans une enveloppe écologiquement durable, économiquement viable et socialement acceptable par les agriculteurs des zones arides de l'Afrique subsaharienne. Le principal objectif de ce programme est d'améliorer la sécurité alimentaire des populations rurales et d'alléger la pauvreté par l'arrêt voire le recul de la désertification.
- L'IFDC participe également à l'Action pour la gestion des sols, de l'eau et des éléments nutritifs qui implique un certain nombre d'organisations internationales. Les quatre consortiums qui se sont formés dans le cadre de cette action centrent leurs efforts sur la lutte contre l'épuisement des éléments nutritifs,

la gestion des sols acides, le contrôle de l'érosion des terres et l'optimisation de l'utilisation des sols et de l'eau.

- Le principal facteur qui freine la croissance agricole en Afrique est l'épuisement continu des éléments nutritifs. Tant que ce problème ne sera pas maîtrisé, tous les efforts en vue d'augmenter les rendements des cultures ne changeront pas la tendance au déclin de la production vivrière par habitant. Conscient de cette réalité, la Banque Mondiale a lancé l'Action pour la fertilité des sols (AFS). Afin de sensibiliser davantage les esprits sur l'importance de la restauration de la fertilité des sols, un prospectus sur l'AFS a été distribué lors du Sommet Mondial de l'Alimentation. Un atelier international a été organisé à Lomé au Togo, au début de l'année 1997, en vue de discuter de ces questions et de mettre au point des projets pilotes.
- L'IFDC conduit une recherche qui doit aboutir à la mise au point d'un engrais à diffusion lente destiné à l'élevage industriel de poissons de mer. Les matières premières ainsi que les produits seront testés dans une eau de mer synthétique composée à partir des sels utilisés pour la préparation et la maintenance des aquariums d'eau salée.
- L'IFDC a préparé des échantillons de plaques d'apatite synthétique utilisées comme source de phosphate pour des expériences hydroponiques à bord de la navette spatiale de la National Aeronautics and Space Administration (NASA). Ces plaques pourront servir ultérieurement sur des stations spatiales.
- Le personnel de l'IFDC a effectué des analyses économiques et financières portant sur les coûts éventuels de la production et de la distribution, pour l'utilisation directe, du phosphate naturel provenant du gisement de Kodjari au Burkina Faso.
- Des échantillons du phosphate naturel de la Tunisie et de l'Algérie ont été caractérisés du point de vue minéralogique et chimique afin de déterminer leur aptitude pour l'application directe. Le même travail a commencé avec le phosphate naturel de la Jordanie.

Systèmes de gestion de l'information

- En collaboration avec l'Instituto Nacional de Investigacion Agropecuria et une organisation non gouvernementale, des chercheurs de l'IFDC ont calibré et validé les modèles de CERES-Blé et CERES-Orge pour les régions productrices de ces céréales dans les Pampas de l'Uruguay et de l'Argentine. Des données sur l'utilisation des intrants, les effets des pesticides et les rendements en grains, qui ont été collectées sur plus de 1 000 champs de blé durant une période de 5 ans ont été utilisées pour élaborer des programmes de gestion des ressources naturelles à l'échelle de l'exploitation. Financé en partie par la Fondation Rockefeller, ce projet relie les modèles de simulation à un Système d'information géographique (SIG) et à un Système automatisé d'évaluation des terres - Automated Land Evaluation System (ALES).
- A la demande de l'Institut International de Recherches sur les Politiques Alimentaires (IFPRI), l'IFDC a préparé une étude intitulée "The role of Fertilizers in Sustaining Food Security and Protecting the Environment: Trends to 2020." Cette étude conçue dans le cadre de l'initiative de l'IFPRI portant sur l'Alimentation, l'Agriculture et l'Environnement vers l'an 2020, analyse les besoins en engrais pour satisfaire la demande alimentaire des plus de 8 milliards de personnes que comptera la planète en l'an 2020 tout en préservant la base des ressources naturelles pour une production vivrière durable. Elle identifie également les diverses contraintes physiques, institutionnelles et de politique qui freinent la fourniture et l'utilisation des engrais nécessaires d'une manière inoffensive pour l'environnement.
- En collaboration avec les Services d'appui à la gestion des sols du Département d'Etat de l'Agriculture des Etats-Unis et le Land Resources Institute de l'Albanie, l'IFDC a réalisé une étude sur les ressources en sol de l'Albanie. Le produit de cette recherche est une carte des sols à l'usage des responsables politiques, des agriculteurs et autres décideurs pour la conception et la mise en oeuvre de pratiques durables de gestion et de conservation des sols. Des cartes précises et fiables sont indispensables pour le succès des mesures de conservation et une gestion plus efficace des sols des bas-fonds afin de réduire la pression de l'agriculture sur les terres marginales.
- Durant l'année 1995/96, des modifications ont été apportées au logiciel du Système d'appui à la décision en matière de transfert de technologie agricole - Decision Support for Agrotechnology Transfer (DSSAT) - en tenant compte de l'application croissante de la modélisation des cultures pour les analyses spatiales dans

les SIG. Tous les modèles de culture peuvent être exécutés dans l'un des trois modes : analyse de saison simple, analyse saisonnière, et analyse séquentielle. La coopération entre les modélisateurs de l'IFDC et ceux de l'Université agricole de Wageningen aux Pays-Bas a abouti à une standardisation plus poussée des structures de données intrants/produits des modèles et l'établissement de normes d'analyse géostatistique et spatiale pour les fichiers intrants des modèles afin de permettre une agriculture de précision.

- En collaboration avec un scientifique du CIAT, des modèles simples de l'utilisation dynamique des sols ont été développés en vue d'analyser les changements intervenus, avec le temps, dans l'utilisation des terres dans une région donnée et d'isoler les principaux facteurs qui entraînent ces changement. Deux modèles simples ont été confectionnés puis testés. Ils comportent des tables de vérification et des ensembles de règles de décision qui déterminent les schémas d'utilisation des terres dans une région donnée.

Développement des capacités humaines

- A la demande du ministère de l'Agriculture et de l'Elevage du Kenya, l'IFDC a organisé en 1996 deux programmes de formation d'une semaine sur : La commercialisation des engrais et la gestion de la fertilité des sols. Ces programmes qui étaient financés par la Banque mondiale, a réuni une grande diversité de participants dont des entrepreneurs, des responsables du ministère de l'Agriculture et diverses coopératives, des compagnies d'engrais et des organisations non gouvernementales.
- L'IFDC a préparé un voyage d'étude pour des responsables de FERQUIMEX/FERTIMINA du Mexique. L'objectif de ce programme qui s'est déroulé au siège et en divers points des Etats-Unis était d'aider ces deux compagnies d'engrais à évoluer vers la privatisation. Les participants ont eu ainsi l'occasion de se familiariser avec les nouvelles technologies et les problèmes qui se posent à l'industrie des engrais .
- En collaboration avec la Fertiliser Association of India et l'Asosiasi Produsen Pupuk Indonesia, l'IFDC a organisé un voyage d'étude sur : La distribution et la manutention des engrais. Des visites en Inde, à Singapour et en Indonésie ont permis aux participants d'observer des activités de distribution physique. Grâce à une meilleure connaissance des besoins en matière de planification, de mise en oeuvre et de fonctionnement des sytèmes de distribution physique, ces hauts responsables pourront mieux assurer la disponibilité des engrais en temps opportun pour les agriculteurs.
- Un programme international de formation sur : Les défis de la commercialisation des engrais a été organisé au siège et en diverses régions des Etats-Unis. Les travaux étaient axés sur quatre thèmes: la technologie de l'information, le labour de conservation, la biotechnologie, et l'agriculture de précision.
- Les modélisateurs de culture de l'IFDC ont participé comme encadreurs au programme de formation de l'Université de la Georgie sur: La simulation sur ordinateur de la croissance et des réponses à la gestion des cultures. Ce programme a permis aux participants de comprendre comment se construit un modèle global de simulation de la croissance végétale et de la dynamique de l'eau et des éléments nutritifs, et de voir comment il peut être appliqué pour résoudre des problèmes du monde réel.
- Deux cadres des Services de production de l'IFDC se sont rendus en Egypte pour former le personnel de l'EFDC aux opérations d'une usine pilote pendant trois semaines. Trois configurations d'usine ont été utilisées pour produire huit différents produits NPK granulés.

Creating Fertile Soil for a Food-Secure World

The earth – the soil – whatever name we use, it is still the foundation of plant life. Webster's *Third International Dictionary* defines it as a "medium in which something takes hold and develops." McGraw-Hill's *Dictionary of Scientific and Technical Terms* refers to it as "freely divided rock-derived material containing an admixture of organic matter and capable of supporting vegetation." Regardless of the definition, we are dependent on soils, and to a certain extent good soils are dependent upon how we use them. Our very living standard is often determined by the quality of our soils and the kinds and quality of plants and animals grown on them. Great civilizations have almost always had good soils as one of their chief natural resources. Moreover, they have remained great only as long as they properly cared for their soils.

The management, restoration, and enhancement of soil fertility are widely recognized as key requirements to the development of global food security and sustainable agricultural systems to feed the world's burgeoning population, which is predicted to approach 8 billion by 2020. With about 90 million people being added to the earth each year, required output gains to feed future generations adequately are only possible if the soil has a plentiful supply of plant nutrients from both organic and inorganic sources to sustain the needed increases in crop yields. Because most soils have limited availability of nutrients, external sources such as mineral fertilizers must supply the necessary nutrients. In recent years the use of mineral fertilizer has come under attack for its possible contribution to environmental ills ranging from nitrate leaching to greenhouse gas emissions to wasteful use of hydrocarbons.

Overgrazing – one of the elements in the process of desertification.

While over-application of nutrients from all sources poses an environmental challenge, failure to replenish nutrients in soils, especially nutrient-poor tropical soils, "can initiate and perpetuate a downward spiral of soil degradation, increased deforestation, and depletion of the natural resource base," ultimately leading to increased poverty, hunger, malnutrition, and environmental degradation. These challenges are discussed in a 2020 Vision Paper published by the International Food Policy Research Institute and authored by Dr. Balu L. Bumb, IFDC Senior Policy Economist, and Dr. Carlos A. Baanante, Director of IFDC's Research and Development Division.

During the mid-1960s many analysts predicted that the world's population was bound for starvation. Few people questioned the importance of fertilizer in increasing food production in the developing countries. Quite the contrary, fertilizer was considered a key component of a technology package – seed, water, and fertilizer – that was responsible for creating the Green Revolution, which helped many food-deficit countries such as India and China achieve food self-sufficiency in a short period of time. More recently fertilizer has been attacked because of heavy use in the developed countries where it is suspected of having detrimental effects through nitrate leaching, eutrophication, and greenhouse gas emissions. Fertilizer use per se has therefore been falsely accused of being an enemy of the environment. Although fertilizer use has increased rapidly in the past few decades, especially in East Asia, it is still too low to cause environmental damage in many developing countries. In fact, in most countries of sub-Saharan Africa, the low fertilizer application rates on food crops are causing nutrient depletion, soil degradation, and low crop productivity. In some areas, such as the Punjab in India, Java in Indonesia, and the Delta region of Egypt, and the export crop sector in Africa where fertilizer application rates are high but unbalanced, the environmental impact should be monitored to avoid potential damage, and balanced fertilization should be promoted.

Drs. Bumb and Baanante predict that fertilizer demand in the developing countries will fall short of the amount needed by 2020 to meet the goals of food security and sustainable development (resource productivity and conservation through nutrient replenishment). Without decisive action, poverty and food insecurity will even become greater problems in many areas of the developing world, especially in sub-Saharan Africa. Additional efforts must be made to promote increased levels of fertilizer use, especially in sub-Saharan Africa. In the future, however, fertilizer's role should be approached differently. Rather than encouraging growth per se, growth in fertilizer use should be promoted in an environmentally sound way.

IFDC emphasizes environmentally sustainable growth so that the goals of food security, natural resource conservation, and environmental protection are not sacrificed. The environmental consequences of too little or too much mineral fertilizer and the importance of organic materials in maintaining soil productivity are two issues that capture the attention of IFDC scientists. They are working with plant scientists and environmentalists to establish the appropriate role that fertilizers must play if agriculture is to be truly sustainable. They want to promote the appropriate use of mineral fertilizers to stimulate crop yields that will in turn provide vegetative cover for soil protection and water conservation. They are truly striving toward sustainable agriculture – the only hope for the future.

As is evident in the following highlights of 1996 activities, IFDC is focusing its efforts to create **Fertile Soil for a Food-Secure World.**

Collaborative Initiatives on Soil Fertility Management

Much of IFDC's work is conducted in collaboration with its partners in the developing world, other international agricultural research centers (IARCs), and multilateral institutions. During 1996 these collaborations continued to strengthen the capacity for agricultural research and development within the national research systems and enabled IFDC to be more responsive to the special needs of developing countries. Four examples of these collaborations are described below.

Combating Nutrient Depletion Consortium

IFDC – Africa and the Tropical Soils Biology and Fertility (TSBF) program in Kenya are the co-convenors of the Combating Nutrient Depletion Consortium for the humid tropics of Africa. Even in the "breadbasket" areas of the moist savanna zones, deficits in essential elements have been detected. This soil nutrient gap results from not only a lack of technical information but also the spiral of human and environmental poverty. To prevent further nutrient depletion, to replenish soil nutrients, and to improve the availability and the use-efficiency of organic and inorganic nutrients, the consortium develops integrated nutrient management practices and policy guidelines and pathways for their adoption. As part of the "Soil, Water, and Nutrient Management (SWNM) program of the Consultative Group on International Agricultural Research (CGIAR), the consortium is one of the four complementary research consortia developing strategies to apply soil, water, and nutrient management practices for sustainable agriculture in the tropics. The other three consortia focus on optimizing soil water use, managing acid soils, and reducing soil erosion. The SWNM program contributes to the ecoregional research and development programs of the CGIAR. The Combating Nutrient Depletion Consortium contributes to the Ecoregional Programme for the Humid Tropics of Africa (EPHTA) by addressing sustainability aspects of nutrient management research. This research considers agroecological and socioeconomic factors and is conducted in benchmark sites within the different ecoregions.

Soil Fertility Initiative

To foster greater understanding of both the factors contributing to soil fertility decline and potential solutions and to act as a catalyst for further participation in the design and implementation of comprehensive soil fertility management programs, the Soil Fertility Initiative (SFI) was organized in 1996 by the Food and Agriculture Organization of the United Nations, IFA, IFPRI, USAID, U.S. Department of State, World Bank, International Centre for Research in Agroforestry (ICRAF), and IFDC. The SFI focuses on the design and implementation of integrated plant nutrient management programs to reverse the trend of declining soil fertility in many parts of sub-Saharan Africa.

IFDC participates in the SFI on both the technical and the policy levels. Information derived from benchmark experiments is applied to provide baseline recommendations on improving and maintaining soil fertility in targeted countries. Market and policy research is conducted, and Governments are assisted in the elaboration of national action plans for soil fertility improvement.

Soil Fertility Management Unit in Burkina Faso

Soil fertility restoration and improvement receive high priority by the Government of Burkina Faso. Within the context of the Sustainable Agricultural Production and Market Development project, IFDC-Africa provides assistance to the Government through the establishment and management of a Soil Fertility Management Unit (SFMU). This unit is responsible for the elaboration of national strategy and action plans for soil fertility recapitalization and improvement. The SFMU promotes linkages among farmers, researchers,

extension officers, policymakers, and all parties concerned with rural development so as to work together toward the goal of promoting sustainable agriculture. Two IFDC-Africa experts and one associate expert have been assigned to the unit since mid-1995. Because many of the Burkina soils are deficient in phosphorus and organic matter, a medium- to long-term strategy is now being developed based on the use of local rock phosphate and organic manure for soil fertility recapitalization. During 1996 a national workshop was co-organized on the subject with representatives of all the main stakeholders in attendance. A consensus was reached concerning the need for a national pilot program for large-scale Burkina phosphate use. The elaboration of this program is now being coordinated by the SFMU and will probably commence during the 1997/98 agricultural season.

Soil Fertility Restoration and Management in Resource-Poor Areas of Sub-Saharan Africa

With funding from the International Fund for Agricultural Development (IFAD), IFDC-Africa, the African Centre for Fertilizer Development (Zimbabwe), and the Tropical Soil Biology and Fertility program began in 1996 a 3-year project aimed at developing integrated soil improvement and nutrient management practices. The hypothesis of the project is that soil improvement leads to higher recovery of applied nutrients and thus to higher yields and/or products of better quality. The ultimate goal of this project is to enhance food security and improve the incomes and employment opportunities of rural farm families in Western and Southern Africa through the exchange of ideas and experiences that enhance the use and sustainable management of indigenous natural resources. The project is being conducted in West Africa and East/Southern Africa in areas where the population density is exceeding the carrying capacity and socioeconomic conditions are favorable. Research and development is executed in close collaboration with two regional networks of national agricultural research and extension services.

Fire as a tool in agriculture, a suboptimal use of nutrients (Ivory Coast).

Exploitation of bushland for firewood contributes to nutrient depletion of soils as crop production does.

IFDC Nutrient Management Initiatives

Taking into consideration the soil, water, and overall environment, IFDC advocates an integrated plant nutrient approach that uses a combination of organic and inorganic fertilizers to increase crop production in an environmentally sound way while providing for food – the most basic of human needs. Effective use and management of plant nutrients are primary components of sustainable agricultural development. Some of the work conducted by IFDC in this area during 1996 is summarized below.

Dr. Leila Ahmad Habib (center), Assistant Professor of Agriculture, Tishreen University, Lattakia, Syria, and Dr. Svetlana Iretskaya (right), Research Chemist, Institute of Technology, Saint Petersburg, Russia, discuss their phosphate rock experiments with Gildardo Carmona, IFDC Coordinator of Greenhouse Services. The two visiting scientists conducted research at IFDC that should help increase food production in their respective countries. Inset photo: Dr. Pearson Mnkeni, a Visiting Scientist and Fulbright scholar from Tanzania, inspects his canola experiment using fertilizer produced from his country's phosphate rock.

Agronomic Evaluation of Phosphate Rocks and Modified Phosphate Products

For several years IFDC has provided services to various fertilizer companies to evaluate the agronomic effectiveness of different phosphate rock sources and their modified phosphate products under different soil and crop conditions. The phosphate rocks evaluated for direct application in 1996 were Gafsa (Tunisia), Djebel Onk

(Algeria), and Eshidiya and El-Hassa (Jordan). The results showed that these phosphate rocks are suitable for direct application to acid soils because of their relatively high chemical reactivity. For low-reactive phosphate rocks, e.g., Jhamarkotra (India) and Jingxiang (China), modifications were needed to improve their agronomic effectiveness. These modifications included compaction of phosphate rock with water-soluble phosphate fertilizers (e.g., triple superphosphate or monoammonium phosphate) at a P_2O_5 ratio = 50:50 and partial acidulation of phosphate rock with sulfuric acid at 50% acidulation level. The results showed that the agronomic effectiveness of these modified phosphate products was greatly improved; some were as effective as water-soluble phosphate fertilizers.

In 1996, three scientists from Russia, Syria, and Tanzania came to IFDC to conduct research on the agronomic evaluation of indigenous phosphate rocks from their countries. One objective of their studies was to determine if certain crop species could use phosphate rock in neutral and alkaline soils. Results indicated that rape (canola) crop absorbed phosphorus from phosphate rocks even in alkaline soils. For example, the low-reactive igneous phosphate rock from Panda Hills, Tanzania, was found to be 50% as effective as water-soluble phosphate in alkaline soils, whereas other crops such as wheat, maize, and soybeans failed to utilize this rock. All of these results suggest that by selecting a proper crop species, it is possible to use the indigenous phosphate rocks even in neutral and alkaline soils where phosphate rock generally is not recommended.

Impact of IFDC Research on Phosphate Use Efficiency in Malaysia

Officials from the Malaysian phosphate industry have credited IFDC researchers with changing the concept of phosphate rock use for direct application in their country. IFDC research has shown that direct application of phosphate rock may sometimes be more cost-effective than the use of water-soluble phosphate fertilizers such as triple superphosphate and diammonium phosphate, under certain soil, crop, and agroclimatic conditions. Primary factors affecting the agronomic effectiveness of phosphate rock for direct application are sources of phosphate rock, soil properties, and crop species. For many years, Malaysian plantation growers had traditionally used the lower reactive rocks without question, but now they know that these are not the best for their acidic soil conditions.

In Malaysia use of phosphate rock for direct application is ideal because of the acidic nature of the soils, relatively high temperature, and high rainfall. These conditions are favorable to the use of phosphate rock for production of long-term plantation crops such as rubber and oil palm. Selection of a proper source of phosphate rock for use, however, requires some understanding of the phosphate rock's properties, which vary widely among rock sources in chemical and mineralogical compositions. As a result of the IFDC research, the Standards and Industrial Research Institute of Malaysia (SIRIM) has now modified its standards to accommodate the use of reactive phosphate rock. One modification is that the requirement of particle size has been revised to 90% passing through 500 μm (32 mesh) from the current 100% passing through 150 μm (100 mesh). The second revision is that the solubility (2% citric acid) expression of phosphate rock has been changed from percentage of total P_2O_5 to percentage of rock. The third one is that SIRIM now recognizes that total P_2O_5 is not relevant to phosphate rock effectiveness. The minimum requirement of total P_2O_5 has been decreased from 30% to 28% to allow reactive phosphate rocks to meet the new specifications. Thus, IFDC research has influenced Government policy regarding the use of phosphate rock for direct application.

Efforts to Improve Nitrogen Efficiency

IFDC's research activities that focus on improving the efficiency of nitrogen fertilizers for applications to flooded rice include work with urease inhibitors to reduce ammonia volatilization losses and experiments with encapsulated calcium carbide (ECC) to reduce losses through denitrification. ECC is a product that releases acetylene into the soil during crop growth. Acetylene inhibits both nitrification and denitrification processes of microorganisms in soils and, thereby, reduces losses of nitrogen from flooded rice soils. The ECC reduced losses of nitrogen in greenhouse experiments on all fertilizer treatments on one soil but had no

effect on the other soil. Nitrogen uptake and yield were increased by ECC even when fertilizer nitrogen was not added to one soil. This work will continue to determine why this promising approach worked with one common rice soil but not with the other. Very promising results with flooded rice have been obtained by Indian and USDA scientists who developed the concept for this product.

The work with urease inhibitors has shown that under tropical rice field conditions it is very difficult to achieve good inhibition and reduce nitrogen losses very substantially. This is likely due to instability of the inhibitors and the very rapid hydrolysis rates in the warm, wet system. IFDC scientists developed a computer model to help predict the profitability of using a urease inhibitor on maize. An effective urease inhibitor that IFDC has studied during the past 12 years is now a commercial product sold in the United States. Using the computer model a farmer can decide whether to use the inhibitor under specific weather and soil conditions in his fields.

Research Involving Long-Term Crop Rotations and Ley Farming Systems in Colombia

Since 1993 an IFDC soil scientist posted at the Centro Internacional de Agricultura Tropical (CIAT) has coordinated a long-term crop rotations and ley farming systems experiment on the Colombian eastern plains in collaboration with CIAT and several other advanced research organizations and national agricultural research systems. This experiment compares a range of agricultural production systems at low and moderate inputs of lime using crop and forage germplasm with contrasting tolerance to soil acidity factors. In this and associated satellite experiments, scientists are studying processes of nutrient cycling, soil organic matter dynamics, and soil physical health to improve the sustainability of production systems for the acid soil savannas. This research has focused principally on the use efficiency and dynamics of nitrogen and phosphorus in monocultures and rotations involving cereal crops, legumes, green manures, and pastures. The highly weathered, acidic soils of the Colombian savannas have a very weak capacity to retain mobile nutrients such as nitrogen against leaching but strongly fix phosphorus into less available forms. The objectives of this work include quantifying the use efficiency of nitrogen and phosphorus, defining the systems that make better use of these nutrients, and developing data bases to assist in the development of system models to overcome the site-specific nature of research and extrapolate knowledge to other sites and scenarios.

Leaching of nitrates derived from fertilizers or green manures and legume residues has tremendous implications not only in terms of the economics of input use inefficiency but also with respect to adverse environmental effects. Previously reported results showed substantial leaching of mineral-N derived from grain legume residues and green manures and large losses of fertilizer-N under rice and maize monocultures. Additional experiments and observations during 1996 confirmed substantial accumulations of nitrogen at depth in soil profiles under cereals throughout the year. Concentrations of mineral-N (on average, from 90 to 120 kg-N/ha with 45%-60% below crop rooting depth) were 5 to 6 times the amount found under native savanna. Furthermore, high concentrations of mineral-N measured under legume rotations moved beyond the rooting depth of the following cereal crop diminishing the N-fixing benefit of legumes in rotations. Consequently, neither green manure nor cowpea residues from the 1995 season had any effect on rice yields during 1996. Other researchers in the project have found low recoveries of nitrogen derived from legumes in these rotations. In contrast, total fertilizer-N recovered in the crop and topsoil from split urea applications ranged from 65% to 85% in these systems. High soil nitrate levels derived from legumes or fertilizers could lead to ground water contamination. Such results illustrate the importance of managing both legume residues and fertilizer-N to control these risks. Significantly, much lower concentrations were found under rotations with improved pastures that root more deeply than annual crops. Such "agropastoral" systems may still provide the most nutrient-efficient agricultural use of tropical savannas.

Phosphorus is the primary limiting nutrient for plant growth on old highly acidic soils such as those of the Colombian savannas. Improved cycling of phosphate fertilizer would greatly enhance the sustainability of agricultural production systems. Studies of soil- P pool sizes (determined by sequential chemical fractionation) under improved pastures and native savanna suggest that the production system has a substantial influence on the partitioning of phosphorus among soil-P pools and, hence, the cycling of the nutrient in

the soil-plant continuum. However, little is known about the dynamics of phosphorus in these soils and which pools are important in these fluxes. During 1995/96, the IFDC/CIAT team studied the effects of the system on seasonal dynamics of labile soil-P fractions in the long-term crop rotations and ley farming systems experiment at Carimagua. In general, inorganic fractions were most influenced by system and fertilizer-P inputs during the study period. The organic phosphorus fractions were generally stable throughout the year suggesting that fluxes into organic-P fractions were very transient and that the pools they represent are all highly labile. During the experiment, most applied phosphorus entered into the labile inorganic-P fractions while there was very little movement either into organic forms or into more recalcitrant forms. This implies both that the residence time of phosphorus in organic pools is very short and that, consequently, phosphorus cycling is very rapid and that rates of P-fixation into the more stable phosphorus forms are low. This agrees with the observations of high residual value previously reported in P-residual value experiments at the same site. Knowledge of the short-term phosphorus dynamics in these systems will aid in devising new soil tests that better reflect phosphorus availability in systems that are low in available inorganic-P and that largely depend on organic-P sources. Moreover, knowledge of factors influencing phosphorus fluxes between soil pools would provide guidance on how to manage systems to enhance phosphorus cycling.

Systems Approach to Nutrient Management

IFDC's soil fertility and systems modeling scientists apply a systems approach to integrated nutrient management. These scientists are conducting research in nutrient dynamics to assess the sustainability of different agricultural production systems in several developing countries. Using crop simulation models, the scientists study the effects of different crop and soil management practices on crop productivity and economic results. Research in this area conducted during 1996 in Latin America and Asia is outlined below.

Soil Fertility Study on Dairy Farms of Uruguay

Inadequate fertilization strategies and the intensification of agricultural production, which occur in the Pampean region of Uruguay, sometimes result in the soil's inability to supply nutrients to crops. To define sustainable plant nutrient and crop management practices for intensive production systems of the region, IFDC collaborated on a project with Uruguay's National Agricultural Research Center (INIA), the Sulfur Institute, Norsk Hydro, and the dairy cooperatives of Uruguay. Dairy production is characterized by large nutrient extractions from the soils and low-nutrient recycling. The soil fertility and maize nutritional status of more than 100 dairy farmer fields were surveyed in a 2-year study. Results of the study indicated that sampled fields presented deficient levels of nitrogen, sulfur, and potassium; whereas, adequate plant content levels of phosphorus, calcium, and magnesium were revealed. These results are very useful in establishing regional research priorities toward improving nutrient cycling and in defining optimal fertilizer strategies for intensive production systems in the region.

Expected Impact of Climate Change on Latin American Agriculture

Large areas of Latin America are affected by current climatic interannual variability related to the length of rainy seasons and the occurrence of extreme events such as droughts or floods. In this regard an IFDC scientist posted in Uruguay, in cooperation with INIA (Argentina), participated in a worldwide study of potential impacts of climate change on world food supply, demand and trade. The global study was coordinated by the U.S. Environmental Protection Agency (EPA), NASA/Goddard Institute for Space Studies, Environmental Change Unit/Oxford University, and the International Institute for Applied Systems Analysis. Using crop simulation models the IFDC and INIA scientists studied the effects of possible climate change on winter crop production in Uruguay and Argentina. Their results indicated that the expected climate change scenarios would result in 10%-30% crop yield reductions. Globally, the study indicated that climate change would have a very small impact on crop production; however, possible negative impacts were primarily observed in low latitudes where most of the developing countries are located.

Integrated Nutrient Management in the Andean Ecoregion

In collaboration with the International Potato Center (CIP), an IFDC systems modeling scientist posted at CIP is conducting a project oriented toward the development and dissemination of the kind of information needed to improve soil and nutrient management in the Andean ecoregion. The goal of this project is to improve the welfare of Andean farming communities by developing sustainable and economically viable strategies for integrated nutrient management. Specific objectives include the following:

- Characterization of crop nutrient requirements for the primary Andean crops and cropping systems.
- Characterization of the principal organic and mineral fertilizer sources potentially available to Andean farmers, including the identification of biophysical, economic, policy, marketing, credit, and social constraints to their effective use.

- Quantitative analysis of primary nutrient cycling processes in Andean farming systems, including the effect of soil erosion on nutrient depletion.
- Development of a dynamic, quantitative, computer-based decision support system to facilitate the identification and evaluation of alternative nutrient management strategies in diverse Andean environments.
- Development of human resource capability to make appropriate nutrient and soil management recommendations based on simple, practical, and reliable methods and effectively analyze production and natural resource management strategies using a systems approach and computer simulation tools.

During 1996 this project focused on assembling data that describe farming practices and the soil and climate resources of sites in Peru and Ecuador. Important links have been established with other ongoing projects at these sites, including the Development of Ecoregional Methodologies (DME) and soil management Collaborative Research Support Program (CRSP) projects, which were started in late 1996. Another important link was established with the Natural Resources Graduate School at the National University of Cajamarca (Peru). A strong emphasis has also been placed on the identification of simulation tools and approaches that might be useful for estimating changes in soil productivity.

A data base of field experiments describing potato yield response to nutrient management has been initiated in Peru. With over 350 studies cited thus far, the data base is constructed to identify who conducted the study, the location, the soil type, the potato cultivars used, and the yield results. This data base will also be useful for identifying suitable studies for model calibration and testing.

A farm-level survey of detailed crop management practices (including nutrient management) for potato-based systems was obtained from an earlier study conducted in Ecuador. These data were originally taken to quantify pesticide management but will now be analyzed to better define nutrient management practices.

A farm-level survey was initiated in Peru to document nutrient management practices. A field study was initiated in Peru to quantify the nitrogen benefits obtained from a traditional animal confinement system where the farmer rotates a portable animal corral across fields between cropping seasons so that the urine and feces of the animals are deposited directly on the field. Extensive frosts late in the year destroyed much of the crop; hence, a new sowing was planned for early 1997.

Construction of a data base that consists of soil profile characteristics, climate, and well-documented field experiments from various sites in the Andes was initiated. The primary purpose of this data base will be to calibrate and test various crop and soil models.

Modeling Resource Dynamics to Address Sustainability of a Rice-Wheat System

Rice followed by wheat is a dominant cropping sequence under a range of management regimes in South Asia with variable productivity. Since 1994 IFDC has been conducting joint research with the International Rice Research Institute (IRRI) on this most important cropping system in Bangladesh, India, and Nepal. The following national agricultural research systems are partners in the collaborative effort: Wheat Research Center in Bangladesh; Environment, Culture, Agriculture, Research, and Development Society (ECARDS), a nongovernmental organization in Nepal; and in India – G.B. Pant University of Agriculture and Technology, Narendra Deva University of Agriculture and Technology, and Indira Gandhi Agricultural University. The main focus of the research has been quantifying environmental and nutrient constraints through ongoing long-term rice-wheat experiments, new intensive information-generating experiments, and simulation modeling. Training scientists from the region on rice-wheat modeling has been an important component of the collaboration.

Both rice and wheat are exhaustive feeders, and the double cropping system is heavily depleting the soil of its nutrient content. A rice-wheat sequence that yields 7 tonnes/ha of rice and 3.9 tonnes/ha of wheat removes as much as 320 kg nitrogen, 30 kg phosphorus, and 335 kg/ha of potassium from the soil. Even with the recommended rate of fertilization in this system, a negative balance of the primary nutrients still exists, particularly for nitrogen and potassium. The rice-wheat cropping effect on nutrient depletion has been observed in long-term experiments; hence, it is not surprising that most rice-wheat soils are low in nitrogen and organic matter.

The requirements of nitrogen, phosphorus, and potassium for high rice and wheat yields vary depending on soil and climatic conditions. Increasing the number of irrigation events significantly increased the grain yield of wheat in many experiments. In the rice-wheat rotation, increasing the nitrogen level up to 120 kg/ha increased the yield of rice; however, there was year-to-year variation in response of rice and wheat cultivars to nitrogen and moisture regimes.

Water availability in the rainfed environment is entirely dependent upon monsoonal rainfall. Since monsoonal rainfall is erratic, rice-wheat farmers in a rainfed environment must accomplish the following: optimize rice transplanting to maximize rainwater availability during the rice season; capture and use residual soil moisture for wheat; and complete wheat grain filling before the onset of high temperatures. Farmers with irrigation sources may not have to wait for the late rain and thus can transplant rice earlier to make full use of high solar radiation early in the season. Subsequently, wheat planting must also be timely to take advantage of early-season low temperatures and avoid high temperatures late in the season. In low- and high-resource input conditions, both crops must use the soil and added fertilizer efficiently to reach their yield potential under this system.

There is limited information on the use of nitrogen in rice-wheat cropping sequences; however, observation suggests that there is an interaction between cultivars, nitrogen rates, and soil moisture regimes experienced during the growing seasons. Experiments were conducted at the Wheat Research Center in Bangladesh to understand the responses of rice and wheat cultivars to nitrogen and soil moisture regimes grown on soils with relatively low-to-moderate fertility levels. The resulting data and results from a long-term experiment at G.B. Pant University of Agriculture and Technology were used to validate and apply existing crop simulation models to a rice-wheat sequence.

Simulation models can be used to extrapolate experimental results to other sites of interest in such variable environments. Simulation investigated year-to-year variation in grain yields of both crops under both nitrogen regimes. Rice yields tended to increase over time, whereas the wheat yields had no definite trend. The simulation results indicated that without nitrogen fertilizer application, nitrogen will be limiting across sites and long-term weather conditions for both rainfed and irrigated crops. Field experimentation quantified actual crop responses to a range of management practices and allowed validation of the models for the rice-wheat sequence. The models were then able to extrapolate and generalize the results for sites in Bangladesh and India.

Advances in Market Development

An Excellent Example of the Impact of the Free Market System

Mohammed Ibrahim's family never had enough eggs. His free-range chickens never produced enough, and good eggs were hard to find in the local market. With high aspirations, he built a poultry shed for 5,000 chickens.

After about 20 weeks, his egg business was doing well. His wife assured him that 4,000 eggs a day was more than enough to feed his family. He sold the surplus (about 3,996 a day) to his customers, but he could not produce enough to satisfy the demand. Determined to keep the farm running well because he had invested his own equity into a new shed, he applied for a working capital loan at a local bank.

Ordinarily, his bank manager would have rejected the loan, but the banker had just returned from an Agrobased Industries and Technology Development Project (ATDP) seminar on Agribusiness Credit Fund (ACF) loans. During those few days, the banker became aware of the feasibility of various agribusiness ventures. Now he saw opportunity where he had formerly seen risk – he decided to fund the loan with ACF monies.

Because Ibrahim was delighted, he invested all his time and effort into his new poultry farming business – Alam Poultry Farms – with a pride uncommon to nonowner-operated concerns in Bangladesh. His new self-financed shed is almost finished, and the community will never have to worry about egg supply again. This story and hundreds of others like it have been replayed throughout Bangladesh recently although with different names and in different agricultural subsectors.

Mohammed Ibrahim is just one of hundreds of entrepreneurs who have benefited from IFDC's Agrobased Industries and Technology Development Project, which is leading the way to food security in Bangladesh.

A vital component of sustainable agricultural development and, thus, food security is the development of a free and competitive market system. The manner in which governments manage the transition to a liberalized market economy determines the prospects for alleviating rural poverty, ensuring food security, and enhancing the quality of life in rural areas.

Much of IFDC's work in the area of market development focuses on agricultural input and output markets, market research, institutional development, management information systems, and credit systems development. Summaries of IFDC's market development activities during 1996 follow.

Impressive Gains in Bangladesh Agribusiness Sector

The Agro-Based Industry and Technology Development Project (ATDP) is being implemented by the Government of Bangladesh, USAID, and a consortium composed of IFDC – as prime contractor, Winrock International, and Ronco Consulting Corporation. The project aims to create competitive markets for agriculture and agribusiness inputs, outputs, and technologies. Agribusiness ventures are being initiated and existing ones expanded with financing from a US $50 million plus agribusiness credit fund.

Fahmida Shireen, IFDC Horticultural Specialist, with a farmer who made an 800% profit from growing and selling baby corn in ATDP's Kapasia Pilot Zone.

IFDC/Bangladesh exhibit booth at the National Seed and Crop Fair, Bogra, Bangladesh, 1996. At the fair 5,000 entrepreneurs were contacted by ATDP officials.

To ensure food security for the rural poor of Bangladesh, the Agribusiness Credit Fund (ACF) of the ATDP project disbursed over $35 million in loans to over 4,000 farmers and agribusiness entrepreneurs during 1996. These loans were disbursed to large, medium, and microenterprises on dairy, poultry, beef fattening, seed production and processing, fish processing, trading in fertilizer, agroprocessing, agrimachinery manufacturers and traders, and also farmers who grow seeds on a contract basis.

The program has worked not only for small individual borrowers but also for larger companies capable of revitalizing entire subsectors. Among the large borrowers is a first-ever international joint venture company

developing seeds locally through a network of contract growers. Every subsector of agriculture is benefiting from the loans. Policies for the fund are established by an ACF Management Committee – consisting of representatives from the Ministries of Agriculture and Finance, the Bank of Bangladesh, USAID, and IFDC, which meets periodically to review the performance of ACF and suggest measures for improvement. For potential loan applicants, ATDP develops project prefeasibility profiles to help them prepare their own project proposals.

During 1996 over 3,000 new agribusiness enterprises were started through the fund, providing enhanced food security in Bangladesh. Private banks are now making loans as never before to manufacturers and processors of agroproducts, seed producers and preservers, and agrimachinery manufacturers.

As part of the ATDP project, the *Agribusiness Bulletin* is published by IFDC/Dhaka each month. The *Bulletin* contains useful information on a variety of topics including agroprocessing; horticulture; seeds; fertilizer; poultry and livestock; agrimachinery; business opportunities; and events, courses, and conferences.

AFADA trade mission in Turkey, June 1996.

Major Progress in Albania

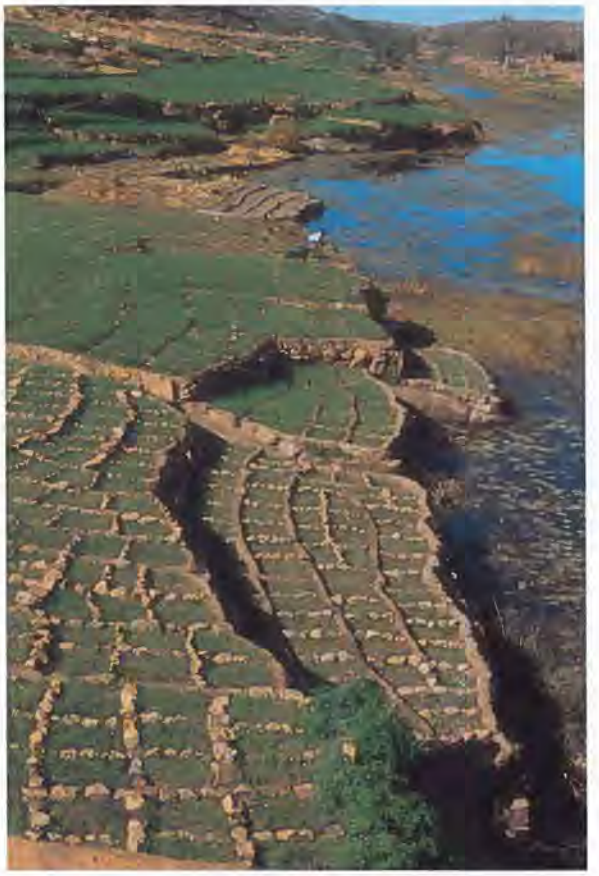
Working with the Albanian Fertilizer and Agribusiness Dealers' Association (AFADA), IFDC has continued to focus on fertilizer importation and development of the markets for quality seed and crop protection chemicals. Privatization of these markets through AFADA dealer development is virtually completed. IFDC facilitated AFADA trade missions to Bulgaria, Germany, Greece, Italy, Turkey, United Kingdom, and the United States to meet with suppliers of agricultural inputs and agroprocessing equipment. These efforts have resulted in long-term relationships with suppliers and joint ventures for the dealers. As AFADA dealers diversify into agroprocessing and agricultural product marketing, IFDC has provided technical assistance in such diverse areas as milk processing, olive oil production, and vegetable exports to European markets. AFADA dealers have also begun to import protein concentrate, which over time is expected to develop into a market for balanced animal feed. This is consistent with Albania's comparative advantage in livestock production.

Institutionalization of the agricultural input dealer network is critical to the sustainability of project activities. IFDC has thus placed a high priority on development of AFADA as an active trade association capable of lobbying the Albanian Government on issues impacting its members, liaising with the country's banking system, stimulating the development of a quality control mechanism for agricultural inputs, and working effectively with international suppliers and organizations.

Throughout the Albania project, IFDC has played a crucial role in the development of credit financing to the agriculture sector and was instrumental in developing credit procedures and convincing bankers to make loans for agricultural inputs. This is a significant achievement in a country that had no private economic activity for a half century under the central command system. Only about 2.5% of the loans that have been disbursed to farmers to purchase inputs remains outstanding.

IFDC-Albania produces two publications. The first, *Biznesi Bujqesor* (Agricultural Business), which has become Albania's primary agricultural magazine, is being privatized in keeping with IFDC's priority on sustainability. The second publication, *AFADA Nofton* (AFADA News), is to be institutionalized as AFADA's newsletter.

IFDC continues to develop AFADA dealers as technological change agents. In cooperation with AFADA, the Center has cosponsored dealer demonstration plots on fertilizer usage and seed varieties. It also has worked with AFADA dealers and their farmer clientele on farm management studies and computer crop modeling simulation. The change agent role of AFADA and its usefulness as a concept that might be applied elsewhere was presented at a workshop on alternative approaches to agricultural extension, sponsored by the World Bank in 1996. AFADA represents a private-sector extension approach that complements and strengthens the existing Albanian public extension effort that is in a formative stage.



Overpopulation stimulates intensification and diversification; production of onion in the Dogon country of Mali.

Market Development in West Africa

Agricultural input and output markets play a key role in farm households' decisions to invest in and improve soil fertility on a sustainable basis. The availability, timeliness, and price of external inputs (used in a broad sense to include credit and information), in combination with the stability and remunerativeness of market outlets determine to a large extent the risk, profitability and thus the adoption of introduced soil fertility enhancing measures. Consequently, introduction and dissemination of appropriate soil improvement technologies should go hand in hand with policy measures that promote the development of conducive input and output markets. This was one of the main conclusions of an international seminar held at IFDC-Africa in November 1996. The seminar, with participants from the public and private sectors of most West African countries, was organized by the Directoraat Generaal voor Internationale Samenwerking (DGIS)-funded project, "Towards Sustainable Agricultural Production and Market Development in West Africa," as part of its program to create input-market transparency to assist West African countries in the elaboration of national strategies for soil fertility restoration and maintenance.

African Fertilizer Market Bulletin

Another important activity of the Sustainable Agricultural Production and Market Development project of IFDC-Africa is the publication of the *African Fertilizer Market*. This monthly bulletin, issued in both French and English, provides its readers with timely information on world fertilizer market and trade developments, with emphasis on Africa. In addition, relevant articles related to fertilizer and soil fertility are incorporated monthly. The *African Fertilizer Market* is distributed to more than 220 persons/institutions throughout Africa, with the objective of improving fertilizer market transparency and efficiency. Now in its seventh year of existence, efforts are being made to make the bulletin even more attractive, relevant to its readers, and sustainable (self funding).

Strengthening Linkages Between Farmers, Fertilizer Dealers, Researchers, and Extension Workers Through Appropriate Policy Reforms, Market Research and Development Activities

With funding from IFA, IFDC-Africa and its partners in the national agricultural research and extension systems of Togo, Benin, and Niger are implementing a project to strengthen linkages between farmers,

fertilizer dealers, research and extension workers through appropriate policy reforms, market research and development activities. One hundred and twenty small-scale farmers, including 30 women, are actively involved in the evaluation of different sources of organic and inorganic plant nutrients. A farmer-managed credit system (Fertilizer Revolving Fund) has been institutionalized in each of the four target communities to provide credit in kind to farmers to fertilize approximately 0.5 ha of cropland. Eighty-five national research and extension workers and other agricultural development professionals in the target regions are being trained in various aspects of agricultural research and development. Field days have been organized in all four communities to allow non-project farmers in adjoining communities, input and output dealers, and policymakers to learn of the project activities.

Assistance to PEQUIVEN's Fertilizer Business Unit/Venezuela

For the past 3 years, IFDC has been assisting Petroquimica de Venezuela S.A. (PEQUIVEN) in the design and implementation of its transition from a previously subsidized enterprise to one that is market driven. The overall goal of this project is to help the company retain its leading position in the marketplace and become competitive in a free market environment. During 1996 PEQUIVEN's total sales of fertilizer products was about 6.5% higher than that of 1995. The total production of products and intermediates from the complex was 14% higher than that of 1995 and 84% higher than that of 1994. The production of granular fertilizers during 1996 was 15% higher than the 1995 production. Plant onstream efficiency was improved greatly during 1996, particularly in ammonia, urea, and NPK. This was primarily a result of concentrated efforts to improve preventive and daily maintenance and continued assignment of small, dedicated maintenance crews to the plants. More than 600 persons from within and outside PEQUIVEN have completed the "Train the Trainer" program on fertilizer marketing, which is entering its fourth year.

Global Fertilizer Market Information

An IFDC fertilizer market information group is providing information services to the world's fertilizer industry. The team produces a set of reports on fertilizer marketing data for a worldwide audience. In addition, the group prepares a series of proprietary reports for members of The Fertilizer Institute (TFI).

Based upon industry demand for these publications, it is clear that they are valuable information sources for fertilizer producers, importers, traders, investors, and policymakers in developed and developing countries. A few of these publications include: *Recent Fertilizer Project Announcements and Proposals (Worldwide); A Guide to Fertilizer Products for Traders; Worldwide Potash Capacity Listing by Plant; Worldwide List of DAP Manufacturers and Traders; Worldwide Directory of Fertilizer Traders, Importers, and Organizations; Worldwide Urea Capacity Listing by Plant; Worldwide Ammonia Capacity Listing by Plant; and North America Fertilizer Capacity.*

The market information group also works with IFA and the Food and Agriculture Organization of the United Nations (FAO) in the estimation of fertilizer use by crop in about 80 countries around the world.

Human Capacity Building

The missing link in many developing countries is human capacity building. Insufficient institutional capacity exists to carry forward programs to help make the countries food secure. To help alleviate this problem and fill in some of the missing links, IFDC continues its commitment to organize training opportunities to meet the changing needs of a dynamic agricultural sector and to address the emerging issues of environment, sustainability, women in development, equity, and private-sector microenterprise development.

In 1996 the Center enhanced the skills of 365 individuals from 57 countries in group and specialized training programs. The topics covered in the programs included fertilizer marketing, soil fertility management, distribution and handling, crop modeling, and environmental challenges. Included among the participants were private agribusiness professionals, entrepreneurs, government policymakers, agriculturalists, and research scientists from the developing countries worldwide. Most of the training programs at IFDC are developed and implemented in collaboration with its partners – national and international agricultural research organizations, universities, agribusiness industry, private voluntary organizations, government agencies, and United Nations organizations. This provides the training participants access to a broad range of expertise and knowledge and provides them the skills necessary to improve their job performance in their countries. During 1996 a number of organizations requested IFDC to arrange special training programs and international study tours to meet their own special requirements, e.g., to provide assistance in making the transition toward privatization. IFDC continues to develop training programs to meet the emerging needs of the agricultural sector and help build the institutional capacity needed to create food-secure societies.

A Kenyan farmer discusses fertilizer use recommendations and application techniques with Ram S. Giroti, IFDC Director, Human Resources Development.

Financial Highlights

The following is a summary of financial information for the year ended December 31, 1996. The full financial statements and the independent auditors' reports are available from IFDC upon request.

Balance Sheet

For the year ended December 31, 1996

	US $'000
Assets:	
Cash and cash equivalents	889
Short-term investments	195
Contributions receivable	645
Contracts receivable, net of allowance for doubtful accounts of $170,285	1,391
Other receivables	100
Supplies inventory	130
Prepaid expenses	33
Total current assets	3,383
Buildings and equipment, net	2,656
Total assets	6,039
Liabilities and Net Assets:	
Current portion of lease payable	14
Accounts payable	606
Accrued annual and sick leave	352
Deferred revenue	349
Total current liabilities	1,321
Lease payable, less current portion	66
Total liabilities	1,387
Unrestricted net assets	4,652
Total liabilities and net assets	6,039

Statement of Revenue and Expenses

For the year ended December 31, 1996

	US $'000
Revenues and Support:	
Bureau of Alcohol, Tobacco, and Firearms	181
Centro Internacional de Agricultura Tropical	70
Egyptian Fertilizer Development Center	64
Foskor Limited	50
International Fertilizer Industry Association	104
Netherlands Ministry for Development Cooperation (DGIS)	666
Ocean Farming Inc.	49
Petroquimica de Venezuela S.A.	985
Rockefeller Foundation	65
The Fertilizer Institute	116
The World Bank	295
U.S. Agency for International Development	6,127
Winrock International	402
Training Programs	150
Others	564
Total revenues and support	9,888
Expenses:	
Field programs	1,502
Research	1,612
Outreach	5,327
Supporting activities	1,719
Total expenses	10,160
Decrease in unrestricted net assets	**(272)**

IFDC Revenue Sources

Bureau of Alcohol, Tobacco, and Firearms (BATF)
Egyptian Fertilizer Development Center (EFDC)
Entreprise Nationale du Fer et du Phosphate – Algeria (FERPHOS)
Fertilizantes de Minatitlán S.A. de C.V. – Mexico (FERTIMINA)
Foskor Limited
International Fertilizer Industry Association (IFA)
International Fund for Agricultural Development (IFAD)
Jordan Phosphate Mines, Ltd.
National Aeronautics and Space Administration (NASA)
Netherlands Ministry for Development Cooperation (DGIS)
Ocean Farming, Inc.
Peace Corps (in kind)
Petroquimica de Venezuela S.A. (PEQUIVEN)
Rockefeller Foundation
The Fertilizer Institute (TFI)
The World Bank
United Nations Industrial Development Organization (UNIDO)
U.S. Agency for International Development (USAID)

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1. Left during 1996.
2. Extended leave.
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Center Profile

IFDC is a public, international, nonprofit organization, which was founded in 1974. The Center focuses on increasing and sustaining food and agricultural productivity in developing countries through the development and transfer of effective and environmentally sound plant nutrition technology and agribusiness expertise. The Center has conducted technology transfer initiatives in more than 100 countries. It has enhanced the development of human resources in more than 140 countries through some 500 training programs.

IFDC's work concentrates on these broad areas: market development; natural resource and environmental management; human capacity building; nutrient access; and nutrient efficiency. IFDC's organizational structure for the 1990s includes three operating divisions: (1) Outreach – which concentrates on technology transfer related to efficient operations of the fertilizer and agriculture sectors; (2) Research and Development – which conducts strategic and applied research in nutrient management and soil fertility; and (3) IFDC-Africa, located in Lomé, Togo – which addresses the constraints to improving agricultural productivity of countries in West Africa.

At present IFDC has offices and/or outposted staff located in Albania, Bangladesh, Burkina Faso, Colombia, Niger, Peru, Philippines, Togo, Ukraine, Uruguay, Venezuela, and Washington, D.C. The Center has linkages with numerous national, international, private-sector, and nongovernmental organizations around the globe. Our partners and clients are diverse and include bilateral and multilateral development agencies, host-government institutions, and private enterprises.

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