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Report

an update on the work & progress at the International Fertilizer Development Center

Headquarters—

Scientists Develop Whole-Farm Decisionmaking Model for Guatemala

By using crop simulation models, IFDC scientists hope to shorten the time between the translation of research findings into the development of new agricultural technology packages and their application in farmers' fields. However, to do this successfully requires an appreciation of the biological, economic, social, and cultural constraints that impinge on small-farm production systems in developing countries. One way of attempting to deal with all of these factors is through the use of whole-farm modeling.

(Photo by Charles E. Butler)

Dr. Gareth Edwards-Jones, Research Fellow, the Scottish Agricultural College, Edinburgh, and Dr. Philip Thornton, IFDC Economist/Systems Modeler, work on an aspect of the whole-farm decisionmaking model for Guatemala.

In this light, IFDC recently added a new dimension to its modeling program—a socioeconomic component. In this effort, the scientists are studying the farmers' decisionmaking process. In other words, they are trying to answer the question, "Why do farmers do what they do?" They are investigating how the interaction between a farmer's social and cultural background, his financial situation, and his natural resource base determines his farming system.

IFDC scientists, in collaboration with their counterparts at other institutions, are presently helping to develop a whole-farm decisionmaking model for Guatemala. Dr. Gareth Edwards-Jones, Research Fellow, the Scottish Agricultural College, Edinburgh, Scotland, recently visited IFDC to confer with his colleagues, Dr. Philip Thornton, IFDC Economist/Systems Modeler, and Dr. Upendra Singh, Systems Modeler/Soil Scientist, on the Guatemala model. Another collaborator on this project is Dr. Barry Dent, Professor of Resource Management, University of Edinburgh, Scotland.

"The long-term goal of this project is to be able to predict the effect of the adoption of a new technology by the farmer," says Edwards-Jones. "For example, will a new rapid-growing variety of beans—or a new harvesting method—or a new sowing method—fit into the farmer's socioeconomic background?"

The scientists hope to determine if a new nutrient management practice will clash with the farmers' current practices or customs, and if so, what would have to be changed in their customs to encourage them to adopt the new practice. For example, would credit or other aids be the required incentive(s) to persuade them to adopt the new product or practice?

The crop modelers are also trying to answer the question, "If a particular technology is available, who will adopt it (i.e., what type of farmer)?" The farm-level model is being built around the crop simulation models of beans, maize, and sorghum for the Guatemala project.

Models of farmers' decisionmaking behavior are very different from those of biological processes. Much of the information required is qualitative rather than quantitative. In turn, different types of computer programs are required. The handling of qualitative data can be effected through the use of rule-based programs, such as expert systems. In these, a number of rules are set up with particular con-

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IFDC is a public, international, nonprofit organization, governed by an international board of directors with representation from developed and developing countries. The Center is supported by various bilateral and multilateral aid agencies, private foundations, and national governments. IFDC focuses on creating sustainable agricultural productivity and food production in the tropics and subtropics through the development and use of improved and environmentally sound fertilizers and fertilization practices.

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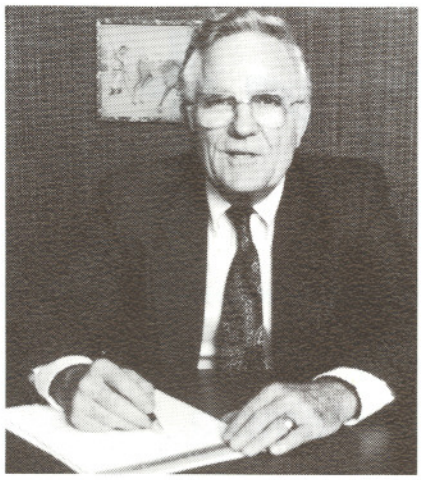
President's Report



(Photo by Charles E. Butler)

Dr. Paul J. Stangel
IFDC President and
Chief Executive Officer

To investigate the possibility of forming partnerships with other international agricultural research centers (IARCs), I traveled to Kenya, Hawaii, and Thailand during the past quarter.

As a result of talks with appropriate personnel of the International Council for Research in Agroforestry (ICRAF), the International Board for Soil Research and Management (IBSRAM), Biological Nitrogen Fixation Technologies for International Development (NifTAL), and the Nitrogen-Fixing Tree Association (NFTA), plans are progressing for collaborative arrangements with these organizations to conduct training programs, research projects, and technology transfer efforts in a number of areas.

Collaboration with ICRAF

Collaborative research between ICRAF and IFDC is now being planned and will focus on the following issues:

1. Establishment of the importance of agroforestry systems in nutrient cycling and improving the efficiency of added nutrients.
2. Understanding the dynamics of nutrient release from the prunings of the nitrogen-fixing trees and the availability of the nutrients to the intercrop.
3. Determination of the nutrient requirement that must be supplied from external sources (inorganic fertilizers and manures) and the fate and efficiency of these nutrients in the agroforestry setting. This will include studies of various phosphate rock sources.
4. Measurement of the distribution and activity of the roots of the legume species in order to estimate their role in nutrient scavenging.

Cooperative Arrangements With NifTAL and NFTA

With NifTAL and NFTA, we envisage a collaboration of research, development, training, and technology transfer in the areas of legume-biological nitrogen fixation (BNF) and agromineral fertilizers. Specifically, cooperative arrangements between NifTAL, NFTA, and IFDC, which are being considered, include training programs and special projects in which the three organizations have a common interest. In addition, the research projects that are being considered for collaboration include:

1. The interaction between soil fertility requirements and BNF from tree and annual crop legumes grown in different agroclimatic zones.
2. The role of mycorrhiza and agrominerals in promoting BNF.
3. The effects of availability of soil nitrogen and soil phosphate on mycorrhiza activity and BNF by various annual crop and tree legumes.
4. Measurement of biological nitrogen fixation (BNF) in various cropping systems and the full evaluation of the benefits accruing to farmers from employing IFDC/NifTAL/NFTA management packages.
5. Possibly adding a BNF component to the rainfall transect research that IFDC now has underway in West Africa.

Linkage With IBSRAM

Closer coordination between IBSRAM and IFDC programs promises to bring a number of benefits that should lead to the development of more effective programs dealing with sustainable land management. Linkage between the two centers brings to the system a wide range of expertise, most notably soil science, socioeconomics, anthropology, nutrient source and supply systems, and policy-related issues. Both IFDC and IBSRAM

have management styles that favor an integrated approach, and consequently a closer coordination between IFDC and IBSRAM has the potential for evolving an overall approach to nutrient use and land management that will be sustainable.

Collectively the two organizations would bring together the necessary expertise to establish an integrated and cost-effective land use, nutrient supply and management system.

IBSRAM and IFDC research programs are geared toward the development of specific environmentally sound nutrient management and land use technologies. Both organizations are producing technologies that reduce nutrient losses due to leaching, volatilization, or soil erosion, thereby minimizing the effects that land management and nutrient supplies have on the accumulation of greenhouse gases in the atmosphere, nitrates and phosphates in groundwater and streams, and heavy metals in the soil.

Both IBSRAM and IFDC employ methodology and monitoring techniques that are closely related and allow ready exchange of data and findings. Closer linkages of the two institutions will allow further standardization of the data bases on land resource management, thus creating one of the largest and potentially effective information sources in the developing world.

Collectively IBSRAM and IFDC have major training programs on site selection, and characterization (both physical and socioeconomic), as well as monitoring and nutrient availability. This type of work could prove to be the initial step necessary to develop a program on effective land resource management.

Conclusion

The forging of collaborative bonds between IFDC and these organizations will not only strengthen all of the training and research efforts involved but also will enable each organization to find innovative ways of making more effective use of donor funds, developing new technologies, and eventually getting these transferred to and used by farmers.

Paul J. Stangel

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sequences for a particular decision. For example, in determining which variety of beans to plant, the following might form a small part of the associated rule base.

If the bean crop is for home consumption
And the rains start early this season
And cash reserves are below a level x
Then plant local bean variety A with a probability of 0.7

There may be many hundreds of such rules in the rule base, and the rules may cover the environmental, biological, climatic, economic, social, and cultural factors that have a bearing on each decision.

Prototype farm models will be constructed for a small number of "typical" farming households, characterized in terms of factors such as natural resource base (soil type, topography, etc.), type of land tenure, attitudes to risk and innovation, and household objectives.

Ultimately it is hoped to integrate the biological-socioeconomic models with a geographic information system to allow regional impact and technology adoption analyses to be performed. A great deal of work is necessary before this stage is reached, but the potential of such an analysis tool is considerable.

When this prototype model is complete, it will be tested in Guatemala first, but it should be possible to modify it to fit the situations in other countries and regions. The development of this type of model adds a powerful dimension to IFDC's crop modeling effort. As the scientists gain a greater understanding of the resource demands of the farm and the limitations of them, as well as the managerial and social implications, they can help pave the way for a more rapid transfer of agrotechnology to farmers and their families. ●

Headquarters—

Granulation Tests Completed for MONOMEROS

At the request of Monomeros Colombo Venezolanos, S.A., in Colombia, IFDC has completed a series of NPK granulation tests that should allow the company to reduce its production costs, increase its production capacity, and eliminate the importation of ammonium nitrate phosphate as a raw material.

Two MONOMEROS staff members—Edgardo Llanos, Head of Economics Group, and Antonio del Risco, Fertilizer Operations Manager—recently visited IFDC Headquarters to observe the tests and consult with IFDC staff.

"Our two main grades of fertilizer are 15-15-15 and 17-6-18-2 MgO," del Risco says. "The purposes of the tests performed at IFDC are to find ways to use more ammonium sulfate in our NPK products and to reduce the nitric acid consumption per metric ton of NPK fertilizer."

According to del Risco the test runs were quite successful. "We think that we can now transfer these pilot plant test results to our commercial operation with a few small modifications," he says.

These tests have provided MONOMEROS with a sound basis to plan and conduct commercial tests in its fertilizer plant. "We have a lot of operating data and a quality analysis of the product," del Risco says.

Llanos is confident of the economic viability of the product as well. "We feel more confident that we can undertake this project, which is designed to reduce production costs and increase production capacity," he says.

George W. Bolds, III, Pilot-Plant Operations Coordinator, was the manager of this project; he was assisted by Jose R. Lazo de la Vega, Special Project Engineer. ●

Headquarters–

Dr. Nyle Brady Addresses IFDC Century Club

(Photo by Charles E. Butler)

Dr. Nyle Brady, UNDP Senior Consultant, addresses the IFDC Century Club at its Annual Banquet on April 2, 1991.

New scientific and agricultural breakthroughs that will help feed the world will be made in the coming years, according to Dr. Nyle Brady, but those successes will be more difficult than in the past because of shifting social and economic problems.

Brady is considered one of the fathers of the green revolution, which led to new agricultural practices that significantly increased the world's food supply in the past 30 years. At the Annual Banquet of the IFDC Century Club on April 2, 1991, Brady pointed out that "sustainable growth, a topic of concern to all earthly creatures, will involve complex and difficult decisions."

Brady, now a senior consultant with the United Nations Development Programme, previously served as senior assistant administrator of the Bureau for Science and Technology in the Agency for International Development.

From 1973 to 1981, he was director general of the International Rice Research Institute (IRRI) in the Philippines. While at IRRI Brady provided intellectual and managerial leadership of international teams that created new rice varieties and technologies that have alleviated hunger for billions of people in low-income rice-eating countries around the world.

The coauthor of three books on the nature and properties of soils, Brady wrote the world's most widely used college text in soil science.

Brady defined his topic of "sustainable development" as a "concept, which envisages farming systems that can be sustainable over a long period of time and that have positive rather than negative effects on the quality of the environment in which the system operates." According to Brady, this concept calls for a sensible balance between pressures for immediate agricultural production and those that can ensure production for our children and grandchildren.

Brady outlined several types of action that must be taken to move toward sustainable agriculture. First, countries need to "plan and implement integrated management programs, including pest-resistant varieties and natural enemies." Soil and crop management that maximizes soil cover with plant residues during periods of high rainfall must continue to be encouraged. Systems must be developed to encourage the absorption of nutrients at lower soil depths by deep-rooted crops and their translocation to the aboveground plant parts where they can be returned to the soil surface and released by microbial action for subsequent crop use. Such systems can simultaneously provide not only nutrient cycling and improved soil properties but also reduced erosion due to good soil coverage. If these systems are supplemented with small quantities of chemical fertilizers, they may well be able to stabilize yields in "slash and burn" areas and make it possible for farmers to remain in one area and not have to move on to other "slash and burned" sites. Much of the research and development activities to enhance sustainable agriculture will require teamwork from different disciplines among international agricultural research centers and national agricultural research and development centers in developing countries. Success of research and development issues will depend to a considerable extent on solution and/or resolution of some national and international policy issues.

For Brady, sustainable agriculture is an achievable goal, but it will need constant attention if it is to be achieved. In seeking viable sustainable agricultural systems, five factors will need to be considered.

First, world human population numbers are increasing at the rate of about 90 million annually—a new United States every 2-1/2 years. These people must and can be fed if proper actions are taken.

Second, deterioration of the quality of soils, water, air, and forest resources must be halted, and agriculture's contribution to this deterioration must cease. On the contrary, steps must be taken to improve the quality of these natural resources.

Third, national policies of both developing and developed countries must be evaluated in terms of their international implication and environmental points of view.

Fourth, means must be found to better assess the complementarity between the judicious use of chemical fertilizers and economic development that is harmonized with environmental quality maintenance.

Fifth, resources to support the role of science in seeking solutions to sustainable agriculture must be forthcoming. Industrialized and developing countries alike must take the long view in providing the needed support. ●

Colombia—

Huila Phosphate Rock: Colombia's Powder With Punch

Roosevel Hernandez, his wife, and three young daughters are realizing the benefits of IFDC-developed technology on their small farm in Colombia. Since Hernandez started using Huila phosphate rock fertilizer on his crops, he has seen his standard of living improve dramatically.

In the past Hernandez grew crops on his 6-hectare farm only occasionally; instead he worked on other farms doing fencing, construction, and agriculture-related jobs. Initially he had only a few coffee trees, but at the suggestion of the IFDC project personnel, he is planting beans, maize, cassava, and some legumes. He used to fertilize his crops with only organic products such as coffee pulp, animal manure, ashes, and vegetable residues. After IFDC scientists established one of their experiments on his farm, Hernandez started using the Colombian phosphate rock fertilizer. He is pleased with the increased yields produced by the indigenous phosphate rock, and the members of his family are reaping the rewards as well.

On the Latin American continent, IFDC has long been involved in research to find energy-efficient, cost-effective alternatives to the more expensive imported phosphate fertilizers by using natural and altered phosphates from countries like Colombia. Dr. Alfredo Leon, IFDC Soil Scientist, stationed at the Centro Internacional de Agricultura Tropical (CIAT) in Cali, Colombia, is continuing his research on the residual effect under field conditions of natural finely ground phosphate rocks and partially acidulated phosphate rocks mixed with urea and two potassium sources. The comparison of the agronomic effectiveness of partially acidulated phosphate rocks from Colombia and Bolivia and of these phosphate rocks compacted with triple superphosphate has been extended to include not only beans but also crops such as upland rice in rotation with soybeans and maize.

Generally additions of low reactive phosphate rocks do not show an immediate effect on crop yields, but with time these phosphate fertilizers start to show positive effects on crop production. IFDC is continuing the study of this important aspect of phosphate fertilization, necessary to economically evaluate phosphate sources.

As a result of IFDC's research and its promotion of Huila phosphate rock as a viable source of phosphate fertilizer, the product is gaining advocates among the Colombian commercial sector as well as among farmers. In fact, 16,000 tons of the country's phosphate rock (approximately one-seventh of Colombia's annual consumption of phosphate fertilizers) is now being sold and consumed on its farmers' fields each year. By using this indigenous fertilizer, Colombia is realizing an estimated savings in foreign exchange of US $640,000 per year.

"After 5 years of research, the Coffee Federation Research Center (CENICAFE) has found that Huila phosphate rock produces the same agronomic effectiveness as do other phosphorus sources such as triple superphosphate, diammonium phosphate, and basic slag," Leon says. "CENICAFE plans to recommend Huila phosphate rock as the least expensive phosphorus source."

As a result of the transfer of technology produced by the IFDC Phosphate Project to Colombian farmers, rice growers in the Eastern Plains are now using 4,000 tons of Huila phosphate rock per year on some 11,000 hectares.

"Colombian sugarcane growers have obtained excellent results using Huila phosphate rock," he says. "They are consuming approximately 1,000 tons of the indigenous product per year."

As a consequence of IFDC research in the Eastern plains of Colombia, farmers are now fertilizing approximately 4,000 hectares of improved pastures with Huila phosphate rock. Their results are excellent and represent important savings in the cost of phosphate fertilization.

Using the Colombian case as a model, IFDC has the expertise to assist other developing countries in finding ways to use their indigenous resources to provide the plant nutrients needed to secure sustainable agriculture. ●

(Photo by Dr. L. A. León)

A Colombian farmer and his wife work in one of IFDC's phosphate experiments. Since part of the IFDC project is being conducted on their farm, they are reaping the benefits of this collaborative work and improving the quality of their lives.

Training Activities

India—

Workshop Presented on Environmental Impact of Ammonia and Urea Production Units

As a result of its interest in the relationship between fertilizer production and the environment, IFDC conducted a workshop on the "Environmental Impact of Ammonia and Urea Production Units" in Bombay, India, during March 25-29.

With financial support from the United Nations Development Programme and cosponsorship of the Fertiliser Association of India (FAI), IFDC presented this first of a series of workshops on the environmental impact of fertilizer production and use. Thirty-nine delegates, including plant managers, fertilizer production specialists, government policy advisers, and other technical advisers, attended the workshop. The delegates were from Egypt, India, Indonesia, Malaysia, Pakistan, and Saudi Arabia.

IFDC Special Project Engineer, M. T. Frederick, and B. K. Jain, FAI Technical Director, served as the workshop managers. Coordinators of the workshop were J. R. Lazo, IFDC Special Project Engineer, and B. Swaminathan, FAI Technical Services. R. S. Giroti, IFDC Training Administrator, was the workshop administrator.

Twenty-three speakers from England, India, Indonesia, the Netherlands, and the United States made presentations during the workshop. Their presentations focused on such topics as environmental standards for fertilizer plants, pollution control strategy, developments in pollution abatement, environmental pollution monitoring, and water treatment and management.

"One objective of the workshop was to identify the impact that the basic nitrogen production units may have on the environment," Frederick says. "In addition, we identified the effluents routinely discharged or intermittently purged from these units and discussed ways to minimize the environmental effects of these discharges."

During the workshop deliberations, the delegates and leaders discussed the methods for coping with the discharges; examined the process modifications, new designs, retrofits, and other advanced process and engineering criteria for decreasing the level of discharges; and reviewed current environmental standards for ammonia and urea production units. Possible future developments affecting the control of ammonia and urea plant effluent discharge were discussed.

"Included on the workshop agenda was a field trip to a large integrated fertilizer production complex, which allowed the delegates an opportunity to view such a facility firsthand and interact with ammonia and urea plant management and technical personnel," Frederick says.

In their evaluation of the workshop, the delegates cited the excellent organization of the workshop program. "It was very well planned and most informative," according to one of the delegates.

Future workshops in this series will focus on the impact of phosphate production and fertilizer use. ●

Zambia—

IFDC Tailors Fertilizer Marketing Program to Meet Zambia's Special Needs

"An eye opener to the commercial world" were the words that Mrs. R. L. Kotowa, Sales Manager of Nitrogen Chemicals of Zambia (NCZ), used to describe a recent training program that was tailor-made for her company by IFDC.

With sponsorship by the Zambia Agricultural Training, Planning, and Institutional Development and with funding from the Zambian Government and the U.S. Agency for International Development, IFDC designed a fertilizer marketing training program especially for Nitrogen Chemicals of Zambia, Ltd.

Officially opening the program was the Honorable J. Mukando, Minister of Cooperatives. "It is hoped that an efficient fertilizer marketing system (for Zambia) will develop programs to enable the less fortunate farmers with no marketable surplus to acquire the equity necessary to obtain fertilizer loans," says Mukando.

Twenty-six people involved in various phases of fertilizer marketing attended the program, which was conducted in Lusaka, Zambia, during April 22-26, 1991. Program manager was IFDC Economist, Gene Harris. Assisting him were Dr. W. E. Clayton, IFDC Transportation/Distribution Specialist; and Ian Gregory, IFDC Marketing Specialist.

In addition to the IFDC core faculty, three outside speakers made presentations. They were Dr. Dynoodt, Agronomist, School of Agriculture, University of Zambia; J. K. McPhillips, Soil Scientist, Mt. Makulu Research Station, Zambia; and Dr. Tareke Berhe, Agronomist, Global 2000.

"This program was especially timely since NCZ is trying to develop a marketing system as it moves from a government-dominated system to a more privatized plan," Harris says. "Under the new system, NCZ will operate more like a business, with responsibility for marketing all of Zambia's fertilizer."

The IFDC marketing specialists provided training on the marketing principles and fundamentals to the NCZ staff. This one-week program was tailored to meet the special needs of Zambia.

The leaders and participants appreciated the excellent arrangements made for the program by Mrs. Margaret Simeza, Fertilizer Marketing Services Manager of NCZ. ●

Headquarters—

Training Program Conducted on Computer Simulation for Crop Growth and Management

Computer simulation models of the soil-crop-atmosphere system can make a valuable contribution to both furthering our understanding of the processes determining crop responses and predicting crop performance in different areas. With the increasing availability of small personal computers, user-oriented simulation models will greatly facilitate the task of optimizing crop and nutrient management.

To transfer information and methodology regarding computer simulation models to developing-country scientists, IFDC organized and conducted a training program at Headquarters during May 6-17, 1991. This program was cosponsored by the University of Florida and the International Benchmark Sites Network for Agrotechnology Transfer.

"The program described the practical approaches to simulating the effects of soil, climatic, and management factors and their interaction with the nutrient needs in crops," says Dr. Upendra Singh, IFDC Systems Modeler/Soil Scientist, and the program's manager. "The participants in this program learned how the processes of crop uptake of nutrients and response to fertilizer can be simulated."

The program attracted 23 scientists engaged in crop production-related research or planning in Argentina, Belgium, Egypt, Ethiopia, France, India, Malaysia, Mali, Mexico, Morocco, Peru, Philippines, Portugal, Republic of South Africa, Tanzania, United States, Venezuela, West Indies, and Zimbabwe.

"During the program we made extensive use of "hands on" practical sessions on microcomputers that demonstrated the application of simulation models to cropping systems in various regions of the world," Singh says. "To add to the practical nature of the program, we discussed methods for assessing the economic risk associated with fertilizer use in a real world problem."

Assisting Singh in conducting the program were the following IFDC staff: Dr. P. K. Thornton, Economist/Systems Modeler; Dr. C. A. Baanante, Economist; and R. S. Giroti, Training Administrator. Visiting faculty included: (from the University of Florida), Dr. J. W. Jones, Professor of Agricultural Engineering; Dr. K. J. Boote, Professor of Agronomy, and Dr. W. T. Bowen, Postdoctoral Associate; (from the U.S. Department of Agriculture-Agricultural Research Service [USDA/ARS]), Temple, Texas), Dr. J. R. Williams, Research Hydraulic Engineer and Dr. V. W. Benson, Agricultural Economist, USDA/Soil Conservation Service (SCS).

"The program participants learned how a comprehensive simulation model of crop growth and nutrient dynamics is constructed and how this can be applied to real world problems," Singh says. "Specifically, the program focused on a description of crop simulation models; their application to fertilizer, cropping, and environmental problems; techniques for data base management; obtaining data for use in simulation modeling studies; and integrating crop models with data base management and geographic information systems." ●

Wan Xia (left). IFDC Systems Modeler/ Research Assistant, discusses an exercise in the training program on Computer Simulation for Crop Growth and Management with Elizabeth B. Yambao, Senior Research Assistant, International Rice Research Institute.
(Photo by Charles E. Butler)

Recent IFDC Publications

(To order publications, please send your request to the IFDC Purchasing Department.)

Application of Crop Simulation Models in Agricultural Research and Development in the Tropics and Subtropics

Authored by Dr. P. K. Thornton, IFDC Economist/Systems Modeler, this publication outlines the various ways that crop simulation models can be applied to management problems. Applications of the models at the field, farm, and regional levels are discussed. For example, at the field level, they can be used to investigate variety selection, nutrient and irrigation use, the timing of planting and establishment in relation to prevailing weather and soil conditions, and long-term soil and nutrient effects on yield stability and sustainability. At the farm level, additional applications include the design and pretesting of new and improved cropping systems and their effects on household viability. At the regional level, linkage to a geographic information system allows the aggregation of production response information for use by researchers and policymakers. This publication will be a valuable resource to scientists and policymakers alike. The price of this publication, IFDC-P-15, is US $4.00 for U.S. addresses/US $7.50 for non-U.S. addresses.

Fertilizer Situation and Markets in Zambia

This publication, prepared by Lewis B. Williams, Consultant (formerly IFDC Marketing Specialist), and John H. Allgood, IFDC Market Analyst, provides an overview of the fertilizer sector in Zambia. Recent trends in fertilizer use are examined, and the domestic marketing system for fertilizers is described. In addition to assessing the current status of research and agricultural extension programs, a brief assessment is made of indigenous raw materials that may be used in fertilizer production. Finally, a forecast is made of fertilizer consumption through 1993.

This publication, which contains maps and a number of statistical

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tables, would be of interest to anyone concerned with the fertilizer sector and agricultural development in the SADCC region and particularly in Zambia. Specifically, this would include commercial companies, international development organizations, donor agencies, and universities, as well as Government of Zambia officials.

The price of this publication, IFDC P-14, is US $4.00 for U.S. addresses and US $7.50 for non-U.S. addresses.

Urea-Based NPK Plant Design and Operating Alternatives: Workshop Proceedings

This proceedings, edited by James J. Schultz, IFDC Fertilizer Production Specialist, and George Hoffmeister, IFDC Consultant, was the outgrowth of a Workshop on Urea-Based NPK Plant Design and Operating Alternatives, which was held September 17-28, 1990. The 23 papers, presented at the workshop, are included in the proceedings. Also included are the questions and answers emanating from the discussion sessions on NPK Plant Design and Operation, Pipe-Cross Reactors, Plant Operating Experiences, Compaction/Granulation Technology, and Agronomic Considerations. An added feature of the proceedings is the inclusion of a bulletin, entitled *Production of Granular NPKs in Ammonium Phosphate Plants—Some Important Differences.*

The price of publication SP-15 is US $30.

World Fertilizer Market Information Sources

This reference manual, prepared by John H. Allgood, IFDC Market Analyst, and Gene T. Harris, IFDC Economist, indexes the sources of fertilizer-related information needed by decisionmakers. Pertinent information on various publications, fertilizer manufacturers, international fertilizer trading companies, and fertilizer-related associations and organizations is contained in this manual.

The price of publication R-9 is US $4.00 for U.S. addresses and US $7.50 for non-U.S. addresses.

Please send your request for publications to the IFDC Purchasing Department.