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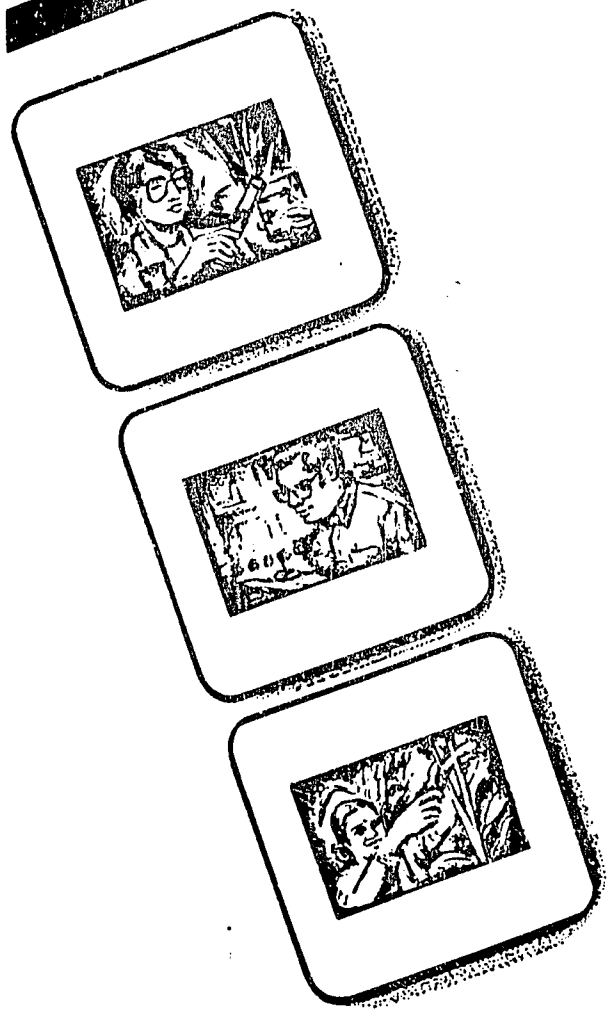
THE IFDC STORY



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PN AAU-977

Countries Served by IFDC

Countries served by IFDC since its inception in 1974.
(as of December 1984)

• Algeria • Bangladesh • Barbados • Benin • Bolivia • Brazil • Burkina Faso • Burma • Cameroon • Chad • Chile • Colombia • Costa Rica • Cyprus • Dominican Republic • Ecuador • Egypt • Gambia • Ghana • Guatemala • Guyana • Haiti • India • Indonesia • Iraq • Israel • Ivory Coast • Jordan • Kenya • Kuwait • Liberia • Madagascar • Malawi • Malaysia • Mali • Mauritania • Mexico • Morocco • Nepal • Niger • Nigeria • Pakistan • Paraguay • People's Republic of China • Peru • Philippines • Saudi Arabia • Senegal • Sierra Leone • Singapore • South Korea • Sri Lanka • Syria • Taiwan • Thailand • Togo • Trinidad • Tunisia • Turkey • Uruguay • Venezuela • Yugoslavia • Zambia • Zimbabwe•

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Photo by Tommy Wright

IFDC main building.

Summary

Background

During the world food crisis of the 1970s, it was recognized that the solution to hunger problems lay in the food-deficit countries themselves. They must produce more food. To help them achieve this goal an international effort was needed to focus on the development of fertilizers and fertilizer practices to meet the special needs of countries of the tropics and subtropics. The U.S. Secretary of State, in a speech before the U.N. General Assembly in April 1974, urged the establishment of a center for this purpose. The center that evolved is today known as the International Fertilizer Development Center (IFDC).

The Center and Its Mission

IFDC is a public, international, nonprofit organization. IFDC's mission focuses on increasing food production through the development of new and improved fertilizer and fertilizer know-how for developing countries. The Center's goals also include the expansion of the use of existing or modified fertilizer materials. IFDC places special emphasis on developing more effective fertilizers for food crops grown under tropical and subtropical conditions.

Specific Objectives

IFDC was created to become a fertilizer research and development center of excellence for the developing countries.

The specific program objectives include:

1. To improve the efficiency of fertilizer used in the tropics and subtropics;
2. To assist developing countries in making better use of indigenous fertilizer resources;
3. To develop fertilizer technology that is appropriate to the constraints of developing countries;
4. To assist in the training of personnel needed in developing countries to produce and market fertilizer;
5. To make available and, where appropriate, transfer technical information and technology on fertilizer production, marketing, and use to developing countries; and
6. To assist national and international agricultural development oragnizations by providing needed technical support to their programs.

International Status

On October 7, 1974, IFDC was officially registered in the State of Alabama as a private, nonprofit corporation. On March 14, 1977, IFDC was designated as a nonprofit, public, international organization.

Board of Directors

The IFDC Board of Directors comes from a varied geographic and technical environment. The Board is made up of 12 members: 6 representing the various regions of the developing world, 3 from the United States, and 3 from other developed nations. They have expertise in chemical engineering, economics, soil science, national and international policy formulation, and administration. Each year these distinguished scientists and administrators review IFDC programs and progress.

Funding

IFDC is funded by international sources. The original sponsors of IFDC were the International Development Research Centre (IDRC) of Canada and the U.S. Agency for International Development (USAID). IFDC is receiving major financial support from other donors, including the United Nations Development Programme (UNDP), the Australian Development Assistance Bureau (ADAB), the International Fund for Agricultural Development (IFAD), and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). Additional funds come from a wide range of national and international agencies for special services provided.

Capabilities

Staff

IFDC's staff, recruited from over 20 countries, is both internationally and technically diverse; almost half of the staff includes senior scientists and administrators. While most of the staff is currently located at Headquarters, an increasing number of staff members are being posted in several developing countries of Africa, Asia, and Latin America. IFDC is able to conduct unique fertilizer research and development because of three complementary factors: (1) the multidisciplinary structure of its staff to participate in research, technical assistance, and training; (2) the ability to produce and test experimental fertilizers in laboratories, pilot plants, and greenhouses; and (3) linkages with key regional and national institutions having an interest in improving food production in the developing world.

Organizational Structure

IFDC is organized into three divisions—Fertilizer Technology, Agro-Economic, and Outreach. Although problems are tackled from a multidisciplinary approach, each division has specific responsibilities.

Fertilizer Technology—The primary function of this division is to develop products and processes to solve immediate and long-term problems of the fertilizer sector. In addition, it develops information relating to the technical and economic factors of fertilizer production. Thus, it can improve conventional fertilizers or develop new fertilizers to meet the needs of tropical and subtropical regions. The scientists and engineers in this division receive information on fertilizer-related technology problems from internal and external sources.

Agro-Economic—Through research at Headquarters and through cooperative programs with other organizations, this division attempts to develop agronomic practices that will increase the efficiency of fertilizer use. The economics research component of this division focuses on the economic evaluation of fertilizer product use; adoption, usage, and demand; and public policy and international issues. This division is also involved in identifying the farmer's needs and constraints and providing research assistance to those who formulate policies to improve the farmer's access to fertilizer. Research information generated by this division serves to help guide research and development of products and processes by the Technology Division.

Outreach—This division is responsible for the dissemination of training information, identification of regional and global problems, technology transfer, market development assistance, and national field programs of an adaptive research nature. Information generated at IFDC and elsewhere is used by Outreach personnel to respond to assistance requests from developing-country organizations.

Much of IFDC's work is planned and implemented by interdisciplinary task teams. These task teams are composed of highly qualified IFDC staff, including agronomists, chemists, communications specialists, economists, engineers, geologists, market development specialists, social scientists, soil scientists, and training specialists.

Photo by Tommy Wright

IFDC boasts several laboratories providing capabilities for conducting a variety of tests.

Location

The Muscle Shoals, Alabama, location was selected so that IFDC could take advantage of expertise and facilities located at the Tennessee Valley Authority's (TVA) National Fertilizer Development Center. TVA's activities are primarily in the United States, whereas IFDC's activities are international. Even though IFDC and TVA are two distinct and separate organizations, the advantages of close proximity are many. We share certain facilities, such as a technical library, which is partially funded by IFDC. TVA's technical library holds the best collection of literature on fertilizers that exists in the world today. TVA also provides security, fire protection, grounds maintenance, some utilities, and some fertilizer raw materials and intermediates on a cost basis to IFDC. By sharing facilities with TVA, IFDC was established at a fraction of the cost required at any other location and became operational in a very short period of time.

Headquarters' Facilities

The IFDC Headquarters' facilities, completed in 1977, are modern and well equipped. The complex includes two buildings. The main building houses offices, specialized laboratories, computers, growth chambers, greenhouses, library, and the media/training center. The engineering research building includes offices and laboratory-scale and pilot-scale fertilizer manufacturing plants.

Laboratories

Nitrogen Research Laboratories—The nitrogen research laboratories use several approaches to improve nitrogen fertilizer, especially urea. Examples of the type of work that is performed in these laboratories include rotary-drum and fluidized-bed coating to control nutrient release, synthesis and evaluation of urease inhibitors, and chemical reactions of urea. Experimental products are evaluated in soil prior to greenhouse evaluation.

In these laboratories soil, plants, and grain are analyzed to determine their total nitrogen content. Using an autoanalyzer system, the concentration of urea, ammonia, nitrite, and nitrate in liquid samples can be determined. An isotope mass spectrometer provides the capability of tracing the route of ^{15}N-labeled fertilizer and determining the amount of fertilizer nitrogen remaining in the soil and plant. The

mass spectrometer is used to conduct ^{15}N analyses for about 10,000 samples each year.

Phosphate Research Laboratory—This laboratory has the capability of comparing the performance of previously untested phosphate ores in chemical processes, such as wet-process phosphoric acid and nitric phosphate. Using the hemihydrate, hemidihydrate, and conventional dihydrate processes, filter-grade and merchant-grade phosphoric acid can be prepared; small quantities of the acid can be converted to such products as ammonium phosphate, triple superphosphate (TSP), and various NPK grades of fertilizers. Various parameters of the processes are evaluated. Nitric phosphates involve two processes: sulfate precipitation and calcium nitrate crystallization. This laboratory also runs corrosion tests on the materials of construction used in the various production processes.

An ultraviolet/visible spectrophotometer is used to determine the concentration of phosphorus present in soil extracts and digested plant material. Using an atomic absorption spectrophotometer, the phosphate research laboratory has the capability of determining the concentration of calcium, magnesium, potassium, zinc, iron, manganese, and other elements present in soil extracts or digested plant tissue.

Sulfur Research Laboratory—The sulfur research laboratory is concerned with the determination of sulfur in plant, soil, and water samples obtained from experiments designed to study the usage and fate of sulfur fertilizers in various soil/cropping systems. The laboratory is equipped with an autoanalyzer interfaced with a microcomputer for automated analysis and data logging of 30 plant or soil samples per hour. A liquid scintillation counter is available for analysis of samples from experiments in which the sulfur fertilizer has been labeled with a radioactive ^{35}S in order to trace that movement of fertilizer sulfur into soil and plant pools. Sulfate-S in water samples and soil leachates is determined in the laboratory's ion exchange chromatograph, which simultaneously determines other leached ions such as nitrate and chloride.

Physical Properties Laboratory—Physical properties of fertilizers are especially important in humid tropical areas. These properties are important in processing, handling and transport, bagging, storage in bulk or bagged form, and application. Recognizing this importance, IFDC maintains a well-equipped physical properties laboratory.

The problems most frequently encountered are (1) dustiness, (2) poor conditioner adherence, (3) caking, (4) low particle strength, (5) particle size segregation, and (6) low critical relative humidity of some mixtures. Other problems are encountered with liquid or suspension fertilizers, although these types are less important in developing countries.

This laboratory conducts several tests to determine the physical properties of various fertilizers. The abrasion resistance test determines the resistance to degradation of the material. This test simulates the handling that the material is exposed to from the producer to the farmer. The hygroscopicity test determines the material's moisture absorption-penetration qualities. The purpose of this test is to determine how well a material will resist deterioration when exposed to humidity levels above its critical relative humidity (that humidity above which the material will absorb moisture from the atmosphere and below which it will not). The bulk-density test determines the amount of a fertilizer material that a certain volume will hold, including the spaces in between granules. Another test determines the angle of repose (the angle to the horizontal that a fertilizer will assume in a bulk pile). This property affects the capacity of storage bins and is of interest in designing roofs of storage buildings.

A controlled temperature-humidity room for bulk and bagged fertilizers simulates tropical storage conditions.

Analytical Laboratory—In addition to equipment used in wet chemical analyses of fertilizers, some specialized instruments are used to support IFDC's research. Examples of these instruments include:

1. X-ray diffractometer used to identify and study crystalline materials.
2. X-ray spectroscope used to provide elemental analyses of solids or liquids from fluorine through uranium.
3. Differential thermal analyzer and thermogravimetric analyzer used to study reactions taking place during heating up to 1600°C.
4. Infrared spectrometer used with solids, liquids, and gases to identify functional groups in molecules through molecular vibrations.
5. Scanning/transmission electron microscope with an x-ray energy dispersion analyzer used for

elemental analysis of materials in microscopic samples.

Other instruments include a differential scanning calorimeter, gas chromatograph, ion chromatograph, and high-pressure liquid chromatograph.

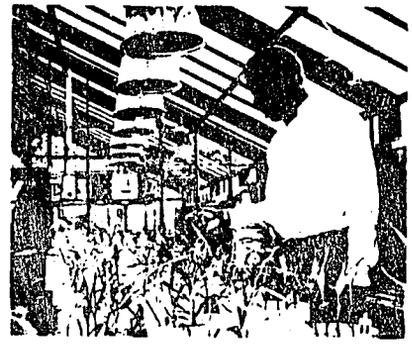
Engineering Research Building

IFDC's engineering research facility allows the Center an in-depth pilot-plant capability in the basic fertilizer processes, wet/dry phosphate ore beneficiation, wet-process phosphoric acid, nitrophosphate-ammonium phosphate-and urea-based NPK granulation and bulk blending. The pilot plants are supported by similar laboratory-scale units to further broaden the overall capability of the facilities.

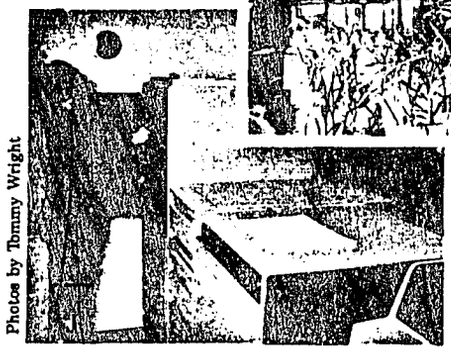
Wet/Dry Beneficiation—These units are designed to study, develop, and demonstrate a variety of phosphate beneficiation processes from simple dry crushing and screening to complex processing including magnetic separation, heavy medium separation, and flotation. Data, including engineering design parameters, can be reliably scaled up to commercial proportions. Examples of beneficiation projects performed by IFDC are:

1. Carbonate flotation of a high-dolomite phosphate rock.
2. Evaluation of alternative flotation reagents for use with high- and low-carbonate phosphate rocks.

Wet-Process Phosphoric Acid—Phosphoric acid is basic to many fertilizer processes. The development of indigenous phosphate deposits often depends upon the feasibility of processing the ore into phosphoric acid, an important intermediate. The pilot plant is designed to evaluate the technical feasibility of such processing including the determination of critical engineering design data such as retention time, filtration rates, sulfuric acid and energy consumption, erosion and corrosion characteristics, and evaporation (concentration) characteristics. The entire unit is constructed of highly resistant stainless-steel and nonmetallic materials; thus, it is suitable for nitric- and hydrochloric-acid based processing. This feature is especially useful when studying phosphate deposits that may be developed in locations where sulfuric acid is not available or uneconomic. Examples of wet-process phosphoric acid projects performed by IFDC include:



IFDC's greenhouses are vital to the work of scientists involved in fertilizer research.



Photos by Tommy Wright

The Center's computing facilities feature the most modern equipment available.

1. Direct acidulation of unbeneficiated, high-silica phosphate rock.
2. Use of unground rock for phosphoric acid production.

Granulation/Bulk Blending—These facilities are used to develop and demonstrate many experimental and most conventional granulation technologies. Since the facilities are relatively large, they are suitable for training of engineers and operators in addition to providing reliable process design and engineering data for commercial scaleup. Large quantities of material can also be produced in these facilities to support in-country agronomic field experiments and demonstrations of experimental or conventional fertilizers. Some examples of granulation projects performed by IFDC include:

1. Urea-based NPK-Mg products and process design using unacidulated phosphate rock as the major source of phosphorus.
2. Urea-based NPK products and process optimization using phosphoric acid (from various sources) as the major source of phosphorus.
3. Nitrophosphate-based NPK products using phosphate rock and phosphoric acid from igneous and sedimentary sources.
4. Granular triple superphosphate using phosphate rock and phosphoric acid.
5. Ammoniated granular triple superphosphate (5-44-0) for application on acid tropical soils.

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6. Evaluation of the effect of impurities in phosphoric acid on the grade and physical properties of diammonium phosphate.
7. Operator training in pan granulation of urea.
8. Production of various fertilizers by compaction-type granulation.

These three pilot plants are an important source of experimental fertilizer materials for field testing. They also serve as training units and provide information for economic and process evaluation.

Growth Chambers and Greenhouses

Fertilizers are used in a wide range of climatic environments. It is important to have facilities that simulate many of the principal tropical and some subtropical environments. Growth chambers have been installed in which temperature, humidity, and light can be varied. Crops such as rice can be grown all year.

IFDC has two greenhouses for conducting experiments to evaluate the agronomic effectiveness of nitrogen, phosphate, sulfur, and other nutrients as fertilizers. Experiments have been conducted on such crops as rice, maize, sorghum, etc.

This research is vital to the development and evaluation of new and modified fertilizer materials before testing in field experiments conducted in collaboration with national institutions and other international centers.

The growth chambers and greenhouse facilities allow IFDC scientists to determine the fertilizer characteristics that a crop needs so that chemists and engineers can develop products that meet these requirements.

Data Processing

IFDC's computing facilities revolve around a Digital Equipment Corporation VAX-11-750 computer system. Twenty-four terminal lines, a 600-line-per-minute printer, a dual-tape drive, two 456-megabyte discs, and a modem are attached to a central processor with four megabytes of memory. Major activities include:

1. Statistical analysis of data from experiments conducted at Headquarters or in collaborating countries;
2. Analysis of socioeconomic data;
3. Processing of data from analytical instruments;
4. Crop modeling and simulation research; and

5. Development and maintenance of various data bases.

There are several microcomputers of various types available; these are generally dedicated to specific applications. Graphics materials can be prepared on graphics terminals and flat-bed plotters.

Library

The IFDC Library provides basic support for all research and training activities at IFDC. Its holdings consist of books, journals, and documents on developing countries and organizations serving developing countries. Using local and worldwide sources, the librarians attempt to fill any reference request ranging from answering a simple question to performing literature and information searches using printed indexes and reference materials or computer data bases.

The IFDC Library has access to the Tennessee Valley Authority's National Fertilizer Development Center Library, which is located nearby. This Library is essential to the IFDC Librarians to service the needs of the IFDC staff and developing-country specialists needing information about fertilizer.

Media Center/Training Facilities

IFDC has a very modern media center and training facilities. The Media Center basically consists of an auditorium, a conference room, photographic studio, and a centralized control room. The auditorium is the main meeting room, having a seating capacity of approximately 75 people. This room is well equipped with audiovisual aids including slide projectors, motion picture projectors, and television equipment. It is normally used for seminars, training programs, and meetings. A smaller conference room is normally used for groups of 15 or less and is also equipped for audiovisual support. A soundproof control/projection room is centrally located to permit showing slides and motion picture film without the distracting noise from the projectors.

A closed circuit television system is installed throughout the IFDC facility and provides bidirectional video capability for recording with a video camera in the various locations and for playback of videotaped programs to television sets.

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Word Processing Center

Serving all units of IFDC is a Word Processing Center; this center is equipped with nine word processors and three ink-jet printers. The word processors are used to record typed material, such as reports, manuscripts, and other copy, onto magnetic diskettes. Recorded material can be recalled as needed for revision and update. Personalized letters can be produced by merging a basic letter with variable names and addresses.

IFDC's Word Processing Center can produce copy in several languages. The Word Processing Center equipment is linked via telecommunications to the typesetting equipment located in the Communications (Publications/Graphics) Unit.

Communications (Publications/Graphics) Unit

IFDC's Communications Unit, serving all divisions of IFDC, has a variety of equipment providing capabilities in phototypesetting; drafting, camera-ready art/publication preparation; production of original slides, slide duplicates, overhead transparencies, and black and white photographs.

By means of telecommunications, the typesetting equipment in the Communications Unit receives copy from the Word Processing Center's equipment. The typesetter and graphic artist arrange the copy in an appropriate layout. Using a photographic process, the hard copy is produced and then used in conjunction with photographs and illustrations to achieve a total product.

The Communications Unit has the capability of editing, typesetting, and preparing camera-ready illustrated copy for printed pieces such as annual reports, newsletters, technical and promotional publications, and brochures.

Research Programs

IFDC maintains its original philosophy of problem identification and solution with emphasis on applied research. Since its inception, IFDC has adhered to the original mandate of improving fertilizer technology, management, and use to increase food production in the developing countries of Asia, Africa, and Latin America.

IFDC's overall research program focuses on: (1) identifying problems related to fertilizer production and use; (2) developing products, processes, or practices to solve these problems; and (3) implementing this technology in given geographic areas.

Nitrogen Research

In its nitrogen research program, IFDC has always followed a three-phase strategy. This strategy is as follows: (1) determining the extent of nitrogen losses from the fertilizers being used, (2) improving use efficiency through modification of materials or management, and (3) developing and testing new fertilizer products, processes, and management practices for lowland and upland cropping situations. The program is enhanced by linkages with several national and international organizations.

IFDC's fertilizer research has focused on improving yields of several crops, but the most important has to be its research to improve yields of rice, one of the *major food crops of the world.* With the adoption of high-yielding varieties, nitrogen is the fertilizer nutrient that most frequently limits higher yields of cereals. This is particularly true for rice.

Urea is the principal nitrogen fertilizer used in most developing countries. In wetland (flooded) rice systems, the rice farmer seldom benefits from more than one out of every three bags of the nitrogen fertilizer that he applies to his rice crop. The remaining two, for all practical purposes, is lost. The potential payoff from improved nitrogen fertilizer efficiency is large. IFDC economists estimate that a one percentage point increase in nitrogen recovery by crops would save US $113 million (1984 dollars) each year.

Research on the fate of fertilizer nitrogen, coordinated by IFDC, spans a wide variety of agroecological systems, for example, (1) irrigated rice and wheat in Asia; (2) rainfed sorghum and millet in the semi-arid tropics of Asia and Africa, (3) rainfed maize in the humid and subhumid tropics of Africa and Latin America; and (4) rainfed wheat and barley in the Middle East.

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IFDC's initial effort in nitrogen research was aimed at wetland regions and started in Asia with rice as the target crop. A collaborative research effort was established between IFDC and the International Rice Research Institute (IRRI). Since 1978 an IFDC scientist has been posted at IRRI in the Philippines.

IFDC and IRRI researchers have shown that the escape of ammonia to the atmosphere as a gas is the principal avenue of loss of nitrogen fertilizer that is broadcast into floodwater. Broadcasting is the most common means of applying nitrogen to rice grown in Asia.

The key to efficient use of nitrogen fertilizer is to keep the ammonium concentrations in the floodwater as low as possible. IFDC engineers and scientists have used three methods to accomplish this. These are: coating the fertilizer to temporarily prevent the urea from dissolving, treating the urea with an inhibitor that slows the decomposition of urea, and deep-point placement of large urea particles. These large urea particles (urea supergranules or briquettes) promise to be the first of a family of nitrogen products to be developed by IFDC's Fertilizer Technology Division that will aid farmers in the developing world to produce more food at a minimum of expense. Of the three methods of reducing nitrogen losses, IFDC scientists have concluded that, over the short term, deep placement of urea has the greatest potential for rice farmers of the developing world.

In 1979 the dryland phase of the nitrogen program was initiated. This program includes the study of nitrogen efficiency on such crops as sorghum, maize, millet, and wheat, grown under dryland conditions in specific agroclimatic zones. The zones of interest are the semiarid tropics, the arid regions, and humid tropics. Within these three regions, IFDC has collaborative projects underway with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria, and the International Institute of Tropical Agriculture (IITA) in Nigeria.

IFDC scientists have made progress in developing more effective sources of nitrogen. They have developed nitrogen products that will both increase nitrogen recovery and improve crop yields. IFDC continues to search for technological improvements

that will curb nitrogen losses in the tropics and subtropics and improve fertilizer nitrogen efficiency in an economical fashion. An active research program has been established to develop cheaper and more active urease inhibitors. Alternative slow-release organic compounds and coatings for urea are screened continuously.

Promising results have been obtained by using the urease inhibitor phenyl phosphorodiamidate (PPD) to reduce ammonia volatilization losses. In IFDC greenhouse tests, ammonia volatilization losses measured were 32% when the inhibitor PPD was not used and only 3%-5% when PPD was applied However, the cost of PPD prohibits its widespread use at present. With GTZ, IRRI, and German University cooperation and support, IFDC is seeking cheaper and more effective inhibitors. Assuming that further developmental research results in such an inhibitor, developing-country farmers will be able to use urea treated with it without modifying their application methods.

Phosphate Research

IFDC's phosphate research program is aimed at helping developing countries (1) develop their own phosphate resources and (2) reduce the costs of producing phosphate fertilizers by the introduction of technology that requires less energy and capital.

The phosphate program deals with characterization of ores from phosphate rock deposits, beneficiation of the ores to produce concentrates, and development of ways to use the material directly as a fertilizer or through some chemical modification to enhance its suitability as a phosphate source for crops.

Some phosphate deposits are small, and many contain impurities such as iron, aluminum, silica, chlorine, or carbonates that preclude their development by conventional beneficiation processes. One of IFDC's first activities was to try to develop beneficiation procedures that would allow such indigenous deposits to be used. IFDC has worked on many of these so-called "problem ores" from several countries and has found solutions that permit the use of many of them. By using a small representative sample (about 5 kg), IFDC's researchers can quickly evaluate most deposits and recommend appropriate processing alternatives. The use of these indigenous materials provides an alternative to imported raw materials or products. A successful operation

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helps to ensure a reliable supply of fertilizer to the farmer and reduces the foreign exchange requirement.

New beneficiation methods have been developed by IFDC and others to upgrade ores with high levels of impurities. Thus, a broader spectrum of rocks can now be used to make single superphosphate (SSP), TSP, or ammoniated phosphates. Also, new techniques have been developed for direct acidulation of unbeneficiated ores. These processes often provide good recovery of the phosphate values, especially in high-silica ores, and can justify some additional sulfuric acid consumption.

One practice that has received increasing attention is direct application of finely ground phosphate rock. Phosphate rocks vary in their reactivity and thus agronomic effectiveness. Some rocks such as Bayovar from Peru give crop yield increases almost equal to those of superphosphates, and others such as Kodjari rock from Burkina Faso give little response in their native state. Response also varies with the soil and with the crop. For example, forage crops and long-season crops fertilized with finely ground phosphate rock usually do better than vegetables and other short-season crops or crops that have high phosphate requirements over a short period of time.

Another interesting development is partial acidulation; only a portion of the acid normally used to make SSP or TSP is used to attack the rock. Agronomic tests on the resulting products indicate that even relatively unreactive rocks can be transformed into useful products, which often give a yield response similar to that with SSP or TSP. Because of the saving on acid consumption and the relatively low capital costs, a number of countries are interested in the partially acidulated phosphate rock (PAPR) approach. Another advantage of this approach is that the sulfur value of the sulfuric acid is retained and available as a nutrient where sulfur is needed.

IFDC has developed a one-step process for partial acidulation and granulation. Such granular materials are of interest because they eliminate dustiness and other difficulties associated with application of finely ground materials. These granulated products are also compatible for mixing and blending with other materials to make a multiple-nutrient fertilizer.

In 1975 IFDC's phosphate field research program in Latin America was initiated in collaboration with

Photo by Dr. John Moraghan

The final test of IFDC's fertilizer technology is carried out in developing countries where the Center has several collaborative projects with other agricultural research organizations.

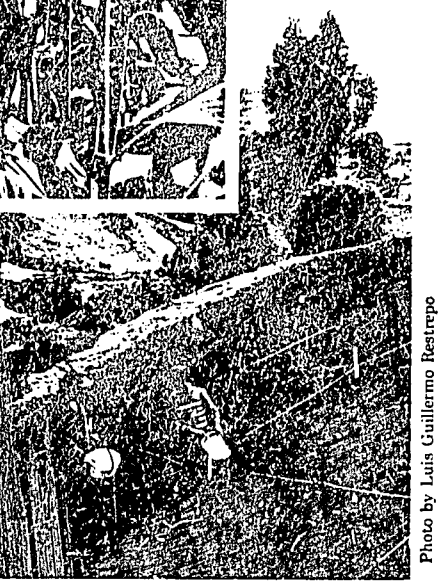

Photo by Luis Guillermo Restrepo

IFDC-developed fertilizers and fertilizer practices are evaluated under a range of tropical and subtropical conditions.

the International Center of Tropical Agriculture (CIAT) in Colombia. A grant from IDRC in 1977 provided funds to expand the project to a number of other Latin American countries possessing indigenous phosphate ores. This research focused on finding solutions to the problems involving the infertile acid soils of tropical Latin America. As a result of the research findings generated by the Colombian project, IFDC's phosphate program has spread from South America to Africa, involving projects in Mali, Niger, Nigeria, and Burkina Faso (formerly Upper Volta).

The phosphate project has taken on a new dimension not only in geography but also in types of crops. Originally the project dealt with beans,

cassava, and forage grasses but later included such crops as potatoes, rice, groundnuts, and sorghum.

Another dimension of the phosphate project is the socioeconomic aspect. IFDC sociologists stationed in Colombia and working in collaboration with soil scientists and agronomists investigate farmer practices in using phosphate fertilizers. This information is used as a guide in designing on-farm trials and evaluating results of farm trials.

Potassium Research

As crop yields improve with the increased use of nitrogen, phosphate, and other nutrients, the need for potassium, in particular, will become more apparent. Recent results suggest that while 40% of the world's nitrogen and 30% of the phosphate are used in developing countries only 16% of the world's potash is used in these same countries. If potassium is not used at a level somewhat comparable to those levels of the other primary nutrients, a further imbalance of critical nutrients will likely result. IFDC will continue to study and monitor the potash status of soils and crops in highly productive systems.

Minerals containing low-to-medium levels of potassium are found in some developing countries. Some of these potassium mineral deposits may become economic for restricted locations within a few countries. In spite of the disadvantages of using carnallite, ores or brines containing this mineral are processed to recover potassium chloride in several developed countries and may be used in the future in developing countries such as Brazil, Thailand, Congo, Jordan, and Pakistan. The opportunity exists to improve technology related to mineral deposits such as carnallite. IFDC is willing to assist interested countries in evaluating local deposits of potash minerals and developing appropriate technologies for them.

IFDC has conducted a major study that analyzed the role of potassium fertilizers in tropical agriculture. This study was also sponsored by the International Potash Institute and the Potash and Phosphate Institute.

In 1981/82 IFDC surveyed 26 countries in the tropics and subtropics concerning their current use of potassium fertilizers. Results of the survey showed that an estimated one-fourth of the soils in these regions are deficient in potassium. (In some areas as much as 70% of the land is deficient.) Crop response to applications of potassium fertilizers varied widely with the crop and the type of cultivar used. But in nearly all cases where there was a potassium deficiency, the yield response was great enough to justify the application.

Sulfur Research

The importance of supplying sulfur to increase crop production is becoming more widely recognized in many parts of the tropics. In the past 20 years, new crop varieties have been introduced, and increased levels of NPK fertilization have been common throughout the tropics. Increased yields have been accompanied by increased sulfur uptake from the soil. Unfortunately, available sulfur in the soil is declining because the new NPK requirements are being met through sulfur-free, high-analysis fertilizers, and the environmental concern for cleaner air has reduced the supply of sulfur from the atmosphere.

IFDC initiated a program in 1979 to (1) promote awareness within tropical regions of the trends that lead to deficiencies of sulfur where they have not existed before, (2) develop an understanding of the mechanisms that influence the efficiency of sulfur applied to overcome deficiencies, and (3) evaluate methods for incorporating sulfur into fertilizer formulations for use in the tropics.

Because of the dynamic nature of sulfur reactions within the soil and the relative lack of precision of the analytical techniques used to measure sulfur, it has been difficult to reliably predict crop response to fertilizer sulfur. IFDC is, therefore, trying to develop a model that will improve such predictions. Considerable data on the effect of liming and nutrient interactions on sulfur availability have already been obtained from Headquarters' research, but a continued effort will be required before a working model can be realized. The reliability of the analytical results is also being addressed at IFDC through studies on improved methodology such as use of ion chromatography.

Concurrent with the studies on sulfur reactions in soils, IFDC has conducted studies on realistic methods of incorporating sulfur in fertilizer formulations in an economic manner. Greenhouse tests suggest that it is possible to fortify TSP with sulfur by using phosphogypsum at levels much less than is contained in SSP. Additionally, IFDC studies conducted with PAPR indicate that this product will

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likely provide adequate quantities of sulfur under most conditions.

IFDC has also completed a study that deals with the economic importance of fertilizer sulfur in the fertilizer industry, food production, and the agricultural sector in the tropical countries of Asia, Africa, and Latin America. The study provides guidelines for future directions in fertilizer sulfur research and public policy.

Multinutrient/Micronutrient Research

When farmers need to use two or more fertilizer nutrients to meet crop requirements or when a micronutrient has to be added annually, multinutrient fertilizers are generally preferred. However, where urea is the major source of nitrogen, the use of conventional granulation technology creates problems. By cooperating with fertilizer producers in countries such as Malaysia, Thailand, and Mexico and engineering firms in North America and Europe, IFDC has been able to make significant progress in solving some of the technology problems. Compaction granulation is one alternative to conventional granulation. IFDC is now exploring the development of processes that use this technology.

A worldwide study of the micronutrient needs and research options was conducted by IFDC. Additional research will be necessary to identify more clearly the geographic regions where micronutrients are most needed.

Economics Research

The profitability of fertilizer use is extremely important. Unless and until a farmer is assured of receiving reasonable returns to his investment on fertilizer, he will not use it. The economics of fertilizer use can be modified through improvements in fertilizer use efficiency and favorable fertilizer policies. The IFDC Economics Program deals with analyzing (1) constraints to fertilizer use at the farm level, (2) the economic evaluation of modified fertilizer, and (3) the economic evaluation of fertilizer-related government policies with the objective of developing guidelines for policymakers of developing countries. A discussion of three examples of economics research conducted by IFDC follows.

Energy Policy Study

In response to a request from USAID, IFDC initiated an energy and fertilizer policy study. The economic and technical aspects of the linkages among energy, fertilizer, and agricultural sectors were analyzed. The main objectives of the study were (1) to estimate energy requirements for fertilizer manufacturing, distribution, and application; (2) to evaluate the policy implications of energy supply and prices; and (3) to evaluate policy alternatives for reducing the adverse impact of energy supply and prices on fertilizer and agricultural sectors.

It was found that about 3.5% of the total commercial energy in the world is used for agricultural production, and fertilizer accounts for about 45% of this energy use. Approximately 81% of the total commercial energy consumed in the fertilizer sector is for fertilizer manufacture. Of this, 90% is for nitrogen fertilizer alone.

The study analyzed ways to save energy and to improve energy efficiency in fertilizer manufacture, distribution, and use. The most promising way to save fertilizer energy is to use fertilizer more efficiently.

Assuming that nitrogen use efficiency in the world could have been doubled, for every 50 million tons of nitrogen used, a potential annual saving of 20 million metric tons of nitrogen (worth US $10 billion) would have resulted during 1978/79. This is equal to a saving of energy equivalent to 262 million barrels of oil (worth US $7.8 billion) or production of 200-300 million metric tons of additional food grain.

Bangladesh Equity Study

Successful adoption of improved fertilizer technologies by the developing countries depends upon the economic return that these technologies can generate in comparison with the existing technologies. For this purpose, different types of economic analyses are carried out to evaluate these technologies in terms of their economic potential at the farm and national level. An example of this type of study is one conducted by IFDC and the Bangladesh Agricultural Research Council on the equity effects of fertilizer use and the identification of various farm-level constraints to fertilizer use and agricultural production in Bangladesh. The results of the study indicated that (1) farmers who own smaller farms (compared with those who own larger farms)

use more fertilizer per unit of cropped area, and they obtain higher crop yields, (2) the benefits of fertilizer use are fairly well distributed among different farm classes, and (3) the use of fertilizer increases farm employment.

Fertilizer Evaluation Program and Information System

IFDC is developing a Fertilizer Evaluation Program and Information System (FEPIS) to (1) promote the use of proper methodologies for fertilizer experimentation and agroeconomic evaluation of fertilizer products and practices, and (2) facilitate access to and exchange of data on fertilizer research results between IFDC and other international agencies and national organizations.

The primary objective of FEPIS is to provide guidelines and technical assistance for systematically conducting the agronomic and economic evaluation of fertilizer products and fertilizer management practices in the diverse agreoclimatic environments of the tropics and subtropics. When operational the system will generate and make information available to researchers and decisionmakers at national and international organizations involved in agricultural research and development. This program will strengthen IFDC's advisory services and training on data analysis, fertilizer evaluation methodologies, and statistical and economic analysis. It will develop services in crop modeling techniques and fertilizer-related research planning.

To achieve the previously stated objectives, the program will have three main components:

1. A fertilizer database system.
2. Data analysis and modeling techniques.
3. Fertilizer efficiency information system.

FEPIS staff members include an agricultural economist, a crop modeler, and a biometrician. Supporting staff members are basically computer programmers and data processing specialists.

National Programs

IFDC realizes that it cannot accomplish its mission without the full partnership, commitment, and participation of key institutions within each developing country. National programs provide a mechanism through which problems are identified and potential solutions are evaluated. The national government determines whether technology merits transfer to the country. IFDC has established such programs in Bangladesh, Indonesia, and Mali.

Bangladesh

IFDC, under the sponsorship of USAID, is assisting the Bangladesh Agricultural Development Corporation (BADC) in overcoming the fertilizer marketing- and distribution-related problems. These problems prevent the expanded and more efficient use of fertilizer needed to raise food-grain production to government planned self-sufficiency levels. IFDC has outposted a three-member team of full-time resident consultants in Dhaka, who assist BADC staff and management in planning, instituting, and monitoring improvements in its fertilizer delivery system.

Indonesia

In Indonesia IFDC is conducting a program of research into the more efficient use of fertilizers for Southeast Asia. This program is carried out in concert with the National Fertilizer Efficiency Program and is coordinated by the Agency for Agricultural Research and Development. To assist the fertilizer efficiency program, IFDC has appointed three resident consultants, based at the Center for Soils Research in Bogor. This program, supported by the Australian Development Assistance Bureau, is composed of four working groups—lowland, upland and industrial crops, and socioeconomic.

Mali

IFDC is helping Mali find ways to use its indigenous phosphate deposit located in the Tilemsi Valley. The project, initiated through funding from IDRC, has acquired additional funding from the World Bank through the Compagnie Malienne Pour le Développement des Textiles. The objective of the Mali Phosphate Project is to select the most efficient and economical source of phosphate to supply to Mali's farmers. IFDC has assisted with the establishment of experiments on 11 experimental stations and farmers' fields. The experiments are providing

Photo by Pierre Rosseau

The ultimate beneficiary of all IFDC endeavors: the developing-country farmer.

valuable information for the extension service to relay to Malian farmers. Malian farmers are now using the phosphate rock fertilizer because it is effective and less expensive than imported phosphates. They are learning that the Tilemsi phosphate rock can significantly increase the yield of their crops, such as cotton, sorghum, maize, and millet.

Photo by Tommy Wright

Technical assistance projects provide a valuable practical service to the fertilizer sector of developing countries.

Technical Assistance

A significant portion of IFDC's efforts is devoted to providing technical assistance. IFDC's staff members, sometimes with relatively short notice, are made available to provide onsite assistance in developing countries for periods of several weeks to several months. Some requests for technical information can be handled by telex or telephone and the less urgent through normal communication channels. This assistance may include helping improve, for example, the production capability of a specific fertilizer plant, increasing the effectiveness of a marketing system, assisting in making a decision relative to pricing policy, or providing guidance on future investments in fertilizer production or marketing. Recipients of this assistance include national agencies, fertilizer companies, governments, corporations, and development organizations. Such assistance is provided on a reimbursable cost basis. (Letters of inquiry regarding IFDC assistance should be addressed to the Managing Director.)

The two primary types of technical assistance provided by IFDC focus on solving production problems and developing marketing systems.

Types of Production Problems Tackled

IFDC has broad and comprehensive experience in helping to solve the most frequently occurring production problems encountered by the small- and medium-sized producers. Types of problems that are often handled by IFDC technical staff include:

1. Process and equipment debottlenecking.
2. Process optimization with emphasis on decreasing production costs.
3. Pollution auditing (field measuring) and cleanup.
4. Maintenance and production management training tailored to specific plant requirements.
5. Maintenance troubleshooting and problem solving.
6. Process design, additions, and improvements.
7. Optimization of packaging and distribution systems.
8. Optimization of in-plant material handling.
9. Quality assurance methods and programs.
10. Production formulations designed to optimize material handling and consumption.
11. Miscellaneous site- and problem-specific assistance and training.

Pilot plants at IFDC are often used to support the technical assistance programs.

Examples of Technical Assistance Provided by IFDC

Company Name	Technical Assistance Activity	Year	Benefit
Monomeros Colombo Venezolanos, S.A. (MONOMEROS) Barranquilla, Colombia	1. Development of bulk-blending strategy using salvaged equipment to complement an existing granulation plant.	1977	Approximately 30% increase (50,000 mt) in production during the first year—25,000 mt of blends and an additional 25,000 mt of granular product because of fewer grade changes.
	2. Process design and engineering assistance for installation of a pipe reactor in an existing granulation plant.	1979	Approximately 75% savings in money and 50% savings in time by using local resources to design, fabricate, and install equipment.
P.T. Pupuk Sriwidjaja (PUSRI) Palembang, Indonesia	Process design, operator training, and startup assistance for urea granulation plant installed to replace existing 300-mtpd prilling tower.	1977-1981	Project completed at about 75% of normal expected cost. PUSRI engineering and operations staff obtained in-depth experience in large-scale modifications and operation of a new-technology plant.
FPM Sendirian Berhad (FPM) Pasir Gudang, Malaysia	Process development (pilot-plant tests), process design, coordination with engineering firms, operator training, and long-term startup assistance.	1979-1983	Construction of plant for approximately 70% of normal cost by assisting FPM in managing entire project and using local resources for all major engineering and equipment fabrication.
Industrias Luchsinger Madorin, S.A. (ILM) Rio Grande, RS, Brazil	1. Study of large granulation plant to determine reasons for low-production performance.	1979-1980	Approximately 30% increase in production during first year due largely to implementing recommended changes in management and improvements in formulation of major grades.
	2. Measurement of all effluent streams from granulation complex and recommendation of modifications and additions to decrease pollution and recover materials.	1980	Approximately 50% savings in time and money needed to implement modifications using local resources. An approximate 5% saving in raw materials is expected when all pollution recovery systems are installed.
Cia. Petroquimica Brasileira (COPEBRAS) Cubatao, Brazil	Production engineering assistance to increase water-soluble P_2O_5 content of superphosphate made from local phosphate rock.	1980	Only slight improvement was made in solubility. These results and efforts of others led to a change in the official specifications for superphosphate produced from locally available phosphate deposits.
Akdeniz Gübre Sanayii, A.S. (AKGUBRE) Mersin, Turkey	Evaluation of existing granulation plant and advice on the feasibility of installing a pipe reactor.	1981	More urgent problems related to the unreliable supply of sulfuric and phosphoric acids were identified. Advised company to delay pipe reactor installation until acid supply problems are resolved.
Petroquimica de Venezuela, S.A. (PEQUIVEN) Moron, Venezuela	Production engineering assistance (formulation and trial operation) during startup of DAP plant that was rehabilitated and converted to NPK production.	1982	Major decrease in dust evolution and pollution and development of production formulations that resulted in products that were within specifications.
Fertilizantes Mexicanos, S.A. (FERTIMEX) Coatzacoalcos, Mexico	1. Production engineering (process and operations) assistance and training in operation of an existing TSP plant that was converted to produce DAP.	1982	75%-100% increase in production within 1 month with only minor modifications of piping and process control methods.
	2. Engineering review of proposed plan to convert TSP/DAP plant to the production of urea-based NPK products.	1983-1984	Project was deferred by FERTIMEX until expected modest production rates indicated by IFDC's experience could be confirmed in pilot plant-scale tests. Studies performed in late 1984 confirmed expectations and implementation of project is continuing.

Examples of the type of technical assistance typically offered or coordinated by IFDC and an estimate of the benefits obtained are shown in the accompanying table. These examples show that major improvement in production and large savings in time and money can usually be made in the plants by investing a relatively small amount of money in technical assistance.

Marketing Systems Development

In addition to the above-mentioned production- and engineering-oriented assistance, IFDC offers expertise and guidance designed to improve fertilizer marketing systems.

A successful fertilizer marketing system can help developing countries to increase food production and at the same time decrease the farmer's fertilizer cost. Successful fertilizer marketing means that the right product is available on a timely basis at the right place and at the right price. Thus, fertilizer marketing involves a series of interrelated steps from the point of production to the farmer. Advertising, agronomics, credit, market research, pricing, projections, storage, transportation, training, wholesaling, and retailing are important aspects of marketing that require attention.

IFDC has a capable marketing staff with many years of practical experience in the international fertilizer industry. These staff members have conducted fertilizer marketing studies for such countries as Bangladesh, Bolivia, Colombia, Ecuador, Indonesia, Madagascar, Mexico, Nepal, Nigeria, Pakistan, Paraguay, Senegal, Sri Lanka, Thailand, Venezuela, Zambia, and Zimbabwe. In addition, market prices and supply/demand statistics are gathered from many developing countries. Reports on the world fertilizer supply/demand outlook, the African Fertilizer Situation, the Asian Fertilizer Situation, the Latin American Fertilizer Situation, and the Fertilizer Situation in Developed Countries are compiled on a regular basis.

A booklet (IFDC G-4) that gives pertinent information on each of the marketing studies conducted by IFDC is available free of charge.

"One of our most valuable products is trained people."—Donald L. McCune

Training

A major philosophy of IFDC is that knowledgeable people will make the difference in solving the problem of world hunger. An increasing number of specialists must be added to the workforce each year in the fertilizer sector if these developing countries are to meet their food production goals. To help people gain the necessary fertilizer knowledge and skills, IFDC has rapidly increased the size and scope of its training component. About 10-12 group training programs are conducted each year. Since IFDC's inception, the number of regional training programs has risen to twice that of the Headquarters' programs. IFDC has conducted training programs in such countries as Bangladesh, Brazil, Cameroon, Colombia, India, Indonesia, Kenya, Malaysia, Mali, Mexico, Nigeria, Pakistan, the Philippines, Singapore, Sri Lanka, and Thailand.

Training activities are focused on three broad fertilizer subject areas: production, marketing, and fertilizer efficiency research. These courses are a mixture of classroom lectures, field observation, and group participation problem-solving situations.

IFDC's group training programs draw upon the experience of a multidisciplinary team of scientists, engineers, marketing specialists, social scientists, and other experts in international agricultural development to provide innovative training sessions. Outside experts supplement the IFDC staff in the various training programs. Appropriate field trips complement classroom sessions. Brochures detailing IFDC's group training programs are available on request.

Photo by Pierre Rosseau

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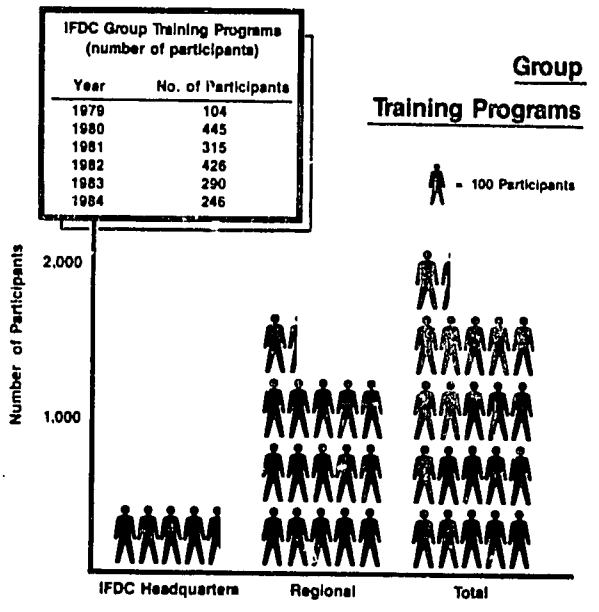
Current group training programs include the following:

Fertilizer Marketing

1. Data Collection, Analysis and Projections in National Fertilizer Sector Studies.
2. Fertilizer Marketing Management Training Program.
3. Fertilizer Marketing Training Program for the African Region.
4. Fertilizer Marketing Training Program for the Latin American Region.
5. Fertilizer Marketing Training Program for the Asian Region.
6. Statistics and Economics of Fertilizer Use
7. Advances in Fertilizer Technology, Marketing, and Use.

Fertilizer Production/Technology

8. Maintenance and Production Management Training Program.
9. Development of Indigenous Phosphate Rock Deposits Training Program.
10. Fertilizer Production Training Program.
11. Regional NPK Fertilizer Production Training Program.
12. Fluid Fertilizer Training Program.



IFDC Programs (1976-84)

Fertilizer Efficiency Research

13. Fertilizer Efficiency Research and Technology Transfer Workshop in Africa.
14. Fertilizer Efficiency Research in the Tropics for Africa.
15. Fertilizer Efficiency Research in the Tropics for Asia.
16. Fertilizer Efficiency Research in the Tropics for Latin America.

A booklet (IFDC G-3) that provides details on each of these training programs is available free of charge.

In the ongoing evaluation of its training programs, IFDC has discovered that 42% of the participants were promoted or changed jobs after attending an IFDC program. Of those, almost 70% indicated that their IFDC training helped in achieving their job change. Sixty percent of the respondents indicated that they had used IFDC training materials in their own organization's training programs while 62% said that they were performing portions of their jobs differently as a direct result of the program(s) they attended.

Individual Training

IFDC also provides training that is designed to meet the specific needs of individuals. Such assignments may be for a few days or several months.

Participants in individualized training programs have studied fertilizer marketing, production, and use; phosphate rock beneficiation; production of wet-process phosphoric acid and nitric phosphate; plant maintenance; and characterization of phosphate rock, to name a few.

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New Horizons

IFDC holds to the philosophy that the solutions to Third World food production problems lie with the people themselves. IFDC is dedicated to helping them help themselves and continues to look for ways to assist in finding these solutions. One way is the establishment of a greater IFDC presence in these regions.

IFDC was created to become a fertilizer research center of excellence for the developing countries. Its continued success depends on how effectively it serves the needs of the fertilizer sector of developing countries.

IFDC pledges to cooperate with other organizations and particularly with the people of developing countries in fulfilling its mission.

Photo by Robbert Wetselaar

The end result of IFDC research—a bountiful supply of food.

Patent Policy

It is the policy of IFDC to acquire patents on the ideas, processes, and products that it develops. The purpose of these patents is to ensure that technology developed by IFDC is available to all organizations in developing countries at a minimal cost.

Information Dissemination

To support the transfer of fertilizer technology, IFDC disseminates information on its research developments through technical bulletins, reference manuals, a paper series, professional journal articles, the quarterly newsletter, and an annual report.

A brochure (IFDC G-1) lists all of IFDC's publications and is available free of charge on request.

A quarterly newsletter, the *IFDC Report*, which is published in English and Spanish, provides short and up-to-date reports on IFDC's activities. If your organization is not receiving this newsletter, it can be added free of charge to the IFDC mailing list upon request.

The Annual Report contains highlights of significant research programs and results and descriptions of IFDC's training, technical assistance, and national programs.

Administration

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Paul J. Stangel, Deputy Managing Director
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Dennis H. Parish, Director, Outreach
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