ANNUAL REPORT 1978

PN-AAS-994

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IFDC publications are listed in the quarterly newsletter the "IFDC Report" and are available upon request.

PN-AAS-994

ISN: 40270

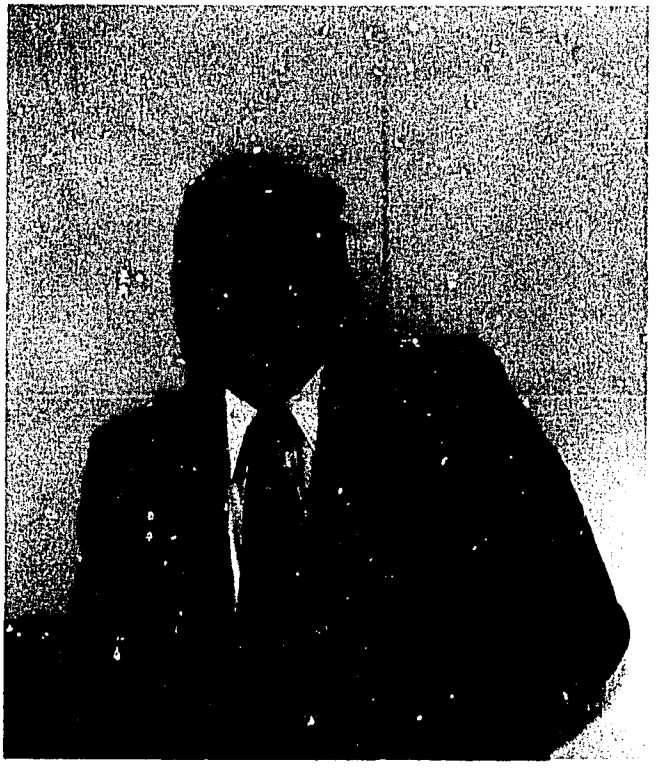
MANAGING DIRECTOR'S LETTER

Fertilizers, along with water and high-yielding varieties, continue to play a major role in increasing world food supplies. Fertilizers are especially important in developing countries where estimates indicate that as much as 50% of the yield increase per unit area can be attributed directly to fertilizer use.

Fertilizer consumption in developing countries in 1978 was more than 26 million metric tons (mt) of plant nutrients (N, P_2O_5, and K_2O), or about 27% of total world fertilizer consumption. These figures can be contrasted with the use of about 11 million mt of nutrients in 1969, or 18% of the world total. International Fertilizer Development Center (IFDC) estimates indicate that by 1985 the developing world will use about 38.5 million mt of plant nutrients which equates to some 28% of the total world consumption of fertilizers. Although fertilizer use is increasing more rapidly in the developing world than in the world as a whole, fertilizer use in the developing world, whether on a per unit area basis or on a per capita basis, is still well below the world average. Fertilizer consumption in the developing world must be increased substantially above present levels if global food targets are to be reached by the turn of the century.

Fertilizer production in the developing world also is increasing at a faster rate than the world as a whole. In 1978 the developing world produced about 17 million mt of plant nutrients, or 65% of total developing country fertilizer consumption. Global production capacity, either installed or under construction, appears sufficient to meet anticipated fertilizer demand for the next 3 to 5 years. Indications are that by 1985 the developing world will produce some 32 million mt of nutrients, or 6.5 million mt less than expected consumption. This deficit will have to be made up through imports.

Fertilizer prices have remained relatively stable since the recovery from the food and fertilizer crises of the early 1970's. Barring any major shortfall in food production



which would cause major increases in crop prices, fertilizer prices are expected to increase only in line with increased production costs. Supply and cost of energy will probably determine—to a large extent—how much and how rapidly fertilizer prices will increase.

Improved fertilizer efficiency and increased use of indigenous raw materials to assure a stable fertilizer supply and to save foreign exchange is the goal of most developing countries. IFDC is continuing its efforts to assist developing countries reach these goals through research and development, technical assistance, and training.

Donald L. McCune

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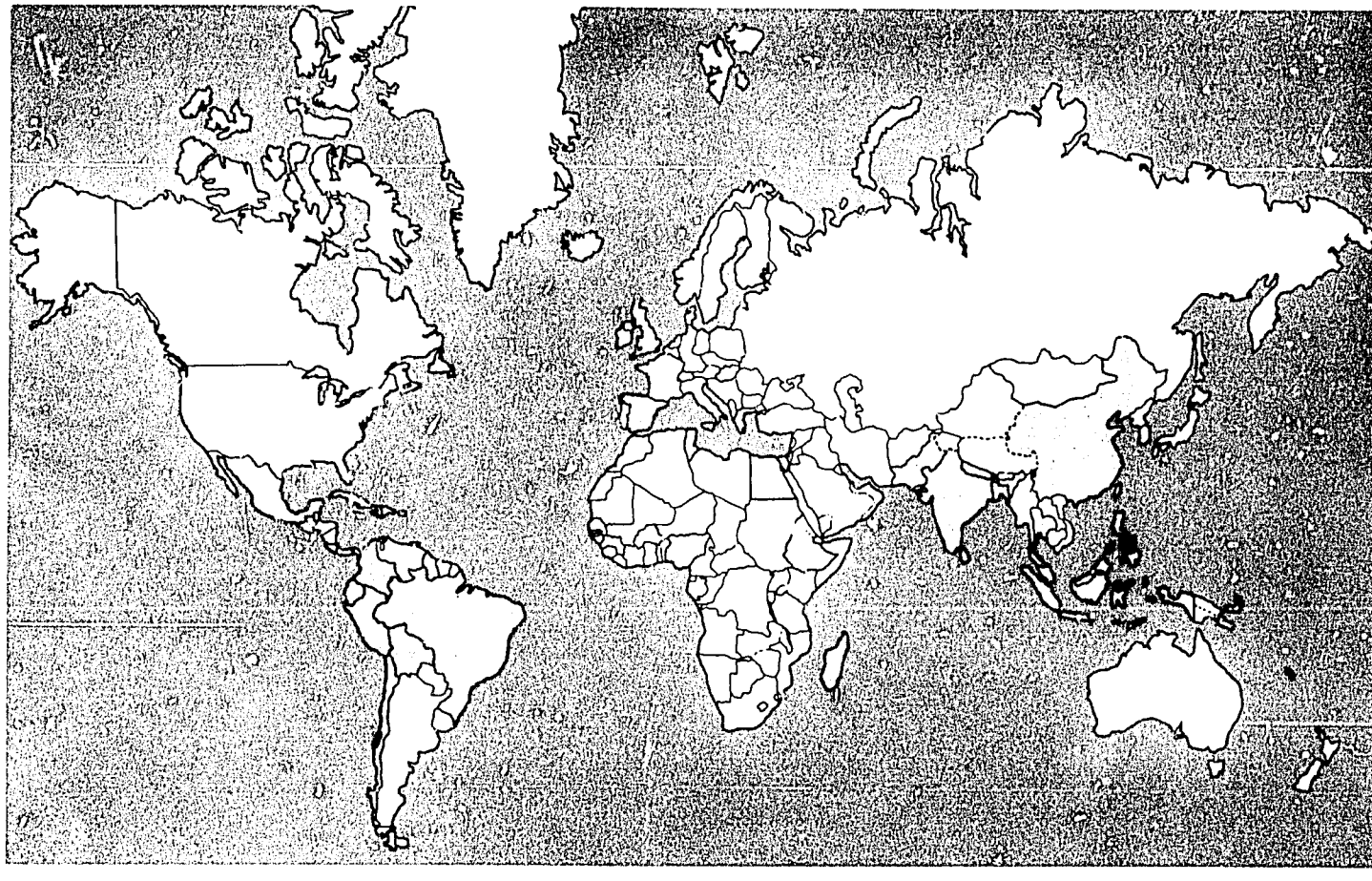
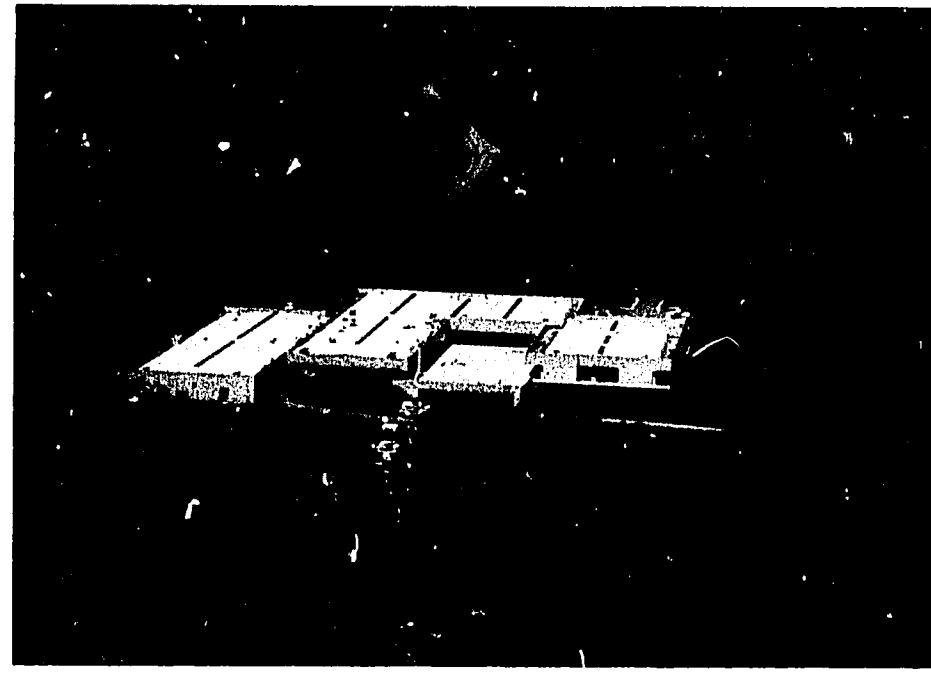


IFDC COUNTRY INVOLVEMENT

Bangladesh	Madagascar
Bolovia	Malaysia
Brazil	Mexico
Chile	Nepal
Colombia	Nigeria
Costa Rica	Pakistan
Ecuador	People's Republic of China
Egypt	Peru
Ethiopia	Philippines
Greece	Senegal
Guatemala	South Korea
Guyana	Spain
Haiti	Sri Lanka
Hungary	Taiwan
India	Thailand
Indonesia	Tunisia
Israel	Upper Volta
Jamaica	



Headquartered in northwest Alabama, IFDC involvement is world wide.

OVERVIEW OF IFDC

Mission Statement

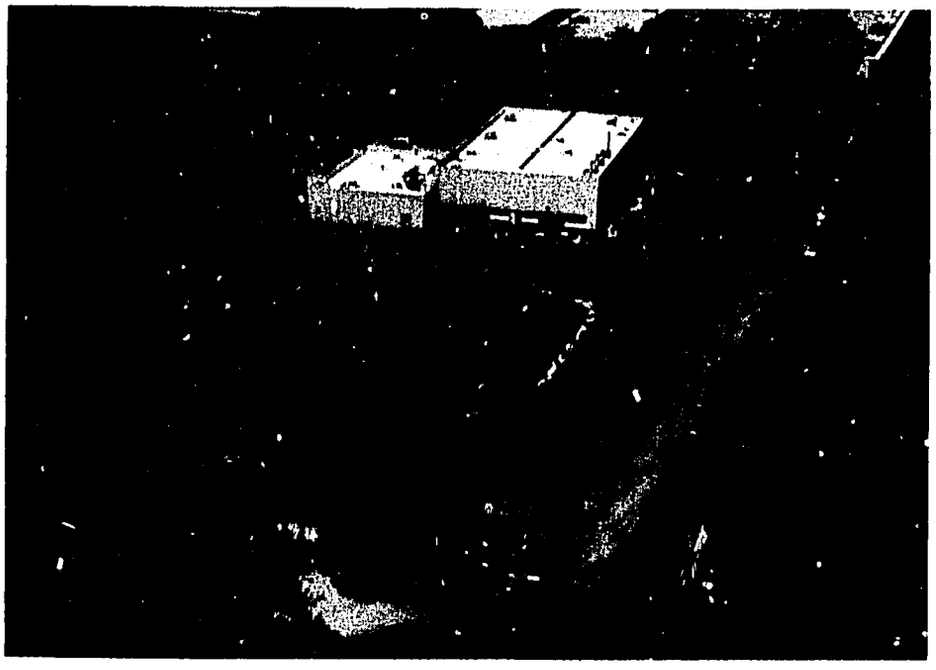
IFDC is dedicated to increasing agricultural productivity in developing countries through the use of improved fertilizers and fertilizer know-how. Program objectives include the development of new fertilizers, as well as expanding the use of current or modified fertilizer materials. Special emphasis is placed on developing more effective fertilizer materials for food crops grown under tropical or subtropical conditions. Special emphasis also is placed on using indigenous raw materials and production capacities where they are technically and economically feasible.

In 1978, more than 500 visitors (not including trainees, salesmen, local students, and candidates for employment) representing 75 countries came to IFDC. Some of the countries that accounted for the largest number of visitors, in addition to the United States, are: Bangladesh, Brazil, People's Republic of China, Colombia, India, Indonesia, Israel, South Korea, Mexico, and Taiwan.

History

IFDC was established as a result of a speech by the U.S. Secretary of State before the United Nations General Assembly in 1974. Secretary Kissinger urged that an international fertilizer research center be established with the purpose of improving the effectiveness of chemical fertilizers in tropical agriculture and discovering new methods to produce fertilizers more efficiently using indigenous resources wherever possible.

On October 7, 1974, IFDC was officially registered in the State of Alabama as a private, nonprofit corporation. On March 14, 1977, President Carter designated IFDC as a public international organization within the United States. Planning funds to establish IFDC came from the U.S. Agency for International Development (USAID) and Canada's International Development Research Centre (IDRC). USAID provided funding for facilities and equipment.



Location

IFDC Headquarters are in Muscle Shoals, Alabama (USA), and are adjacent to the Tennessee Valley Authority National Fertilizer Development Center. The proximity of the two organizations enable them to share facilities, staff, and expertise.

Board of Directors

IFDC is governed by a 12-member Board of Directors—Dr. John A. Hannah, Chairman, United States; Dr. Webster Pendergrass, Vice-Chairman, United States; Dr. Jumpei Ando, Japan; Dr. Fernando Penteado Cardoso, Brazil; Dr. George Cooke, United Kingdom; Sir John Crawford, Australia; Dr. Eduardo Alvarez Luna, Mexico; Dr. S. K. Mukherjee, India; Dr. Bukar Shaib, Nigeria; Dr. Ibrahim F. I. Shihata, Arab States; Dr. Arturo R. Tanco, Philippines; and Dr. Robert Wagner, United States. Their backgrounds, knowledge, and skills provide the guidance necessary for IFDC to fulfill its role as a fertilizer research and development center of excellence for developing countries.

Organization and Staffing

IFDC is organized into an administrative division and three operating divisions —Fertilizer Technology, Agro-Economic, and Outreach—which have the responsibility for executing IFDC programs. Multidisciplinary and interdivisional task teams act as advisory groups on research directions for specific program areas.

IFDC's multinational staff—representing 19 countries—totals 130 full-time personnel. Engineers, chemists, geologists, agronomists, economists, soil scientists, sociologists, market development specialists, and support personnel provide the nucleus for program implementation.

RESEARCH AND DEVELOPMENT

One of the major ways in which IFDC is fulfulling its mission of increasing agricultural productivity in developing countries is through research and development programs. Researchers from Technology, Agro-Economic, and Outreach Divisions work as interdivisional and interdisciplinary task teams on IFDC's problem-oriented programs. Specialized laboratories, pilot plants, growth chambers, and a greenhouse at Headquarters and field plots strategically located at other international centers and through national institutions in developing countries enable IFDC scientists to conduct experiments aimed at developing and improving fertilizer materials and fertilizer know-how.

Greenhouse experiments are being conducted at IFDC Headquarters to determine the relative nitrogen efficiency of various fertilizer materials when used on paddy rice.

Nitrogen Program

Nitrogen is and will continue to be the single fertilizer nutrient most limiting crop yields. Relative to other nutrients it is used in the greatest quantities by farmers throughout the world. Nitrogen fertilizer research is of particular importance in many developing countries where rice is the main food crop.

Focus of Nitrogen Program

IFDC's nitrogen research program is aimed primarily at developing ways to improve the efficiency and to promote the use of nitrogen fertilizers. The potential for increasing response to nitrogen fertilizers through improved use efficiency is great and becomes more important from an economic viewpoint as capital and operating costs of nitrogen fertilizer production continue to climb.

The immediate emphasis of IFDC's nitrogen program has been placed on the fertilization of rice because it is the main food crop for two-thirds of the world population and a major portion of the world poor. In addition, the use efficiency of nitrogen under present rice cultivation practices is poor. The utilization efficiency of urea by rice is likely to be as low as 30% when urea is applied by broadcasting on the surface of the rice paddy.

A 1% increase in the efficiency of nitrogen utilization would save 163,000 tons of nitrogen and result in a significantly larger increase in grain production. Thus, even small improvements in nitrogen efficiency will lead to a lower per unit cost of nitrogen recovered by the plant, an increase in food production, and an improvement in foreign exchange earnings.

Urea is the major source of nitrogen for rice and other cereal grain production. Urea capacity in the developing countries is expected to increase from 10.8 million mt of nitrogen in 1978 to 21.8 million mt of nitrogen in 1985. This growth in production capacity indicates that urea will be the major nitrogen fertilizer source in developing countries for the remainder of this century.

Because urea is often the only nitrogen fertilizer available in developing countries, any research that leads to improved nitrogen utilization efficiency of urea is of major interest. IFDC researchers are studying methods and materials to increase nitrogen efficiency through deep placement—mechanically or by hand—and (or) controlled nitrogen release.

Important factors in selecting each of these modes of controlling losses deals with the understanding of the loss mechanism itself, the factors controlling it, and the feasibility of applying those to conditions in the developing countries.

Investigation of Nitrogen Losses

Losses of nitrogen from the soil-plant system are the primary cause for the poor utilization of nitrogen fertilizers by rice. Nitrogen is lost from the system through denitrification and ammonia volatilization into the atmosphere, through runoff, and through leaching into the lower soil layers.

Considerable research work has been done in identifying the pathways of use and mechanisms of nitrogen loss in rice fertilization. However, much remains unknown, particularly in regard to the use characteristics of new fertilizer materials such as those being developed by IFDC.

Instrumentation and Techniques

The key to understanding the fate of nitrogen fertilizer is to develop equipment and techniques to detect the losses from various modes and to conduct in the field actual nitrogen balance studies. Information gained in this manner is then related to specific agroclimatic conditions for major rice-growing areas.

One method for determining the amount of fertilizer used by a plant is the apparent fertilizer recovery method. Using this method, two plants are treated identically—same soil and amount of water and sunlight—except for amount and timing of fertilizer. At the end of the growing season, the two plants are compared according to rice yield and growth development. The apparent amount of fertilizer used by the plant can be determined by comparing the growth development and yield of the two plants. But this method does not allow for determining the amount of fertilizer left in the soil.

An alternative to the apparent recovery method is to use a tracer nitrogen (15^N) to determine the amount of nitrogen that is contained in each portion of the soil-plant system, including the amount of apparent nitrogen remaining in the soil. During 1978, IFDC researchers used this method to determine the amount of nitrogen fertilizer used by rice growing in two soils using three types of fertilizers. Results of this greenhouse experiment indicated that urea supergranules deep-placed had the highest total recovery of fertilizer as well as the highest percentage of fertilizer in the plant. Ammonium sulfate ranked second, and prilled urea was lowest, although these materials were not deep placed.

In an experiment conducted at Headquarters, IFDC researchers determined the effect of urea placement, percolation, and soil type on leaching losses of urea from flooded soils growing rice. The scientists used model systems in environmental chambers to allow control and variation of water percolation rates.

The results of this research indicated that moderate to high percolation through silt loam soil fertilized with deep-placed urea supergranules leads to significant nitrogen losses and drastically decreases the fertilizer uptake by plants. Conversely, such losses were negligible with broadcast urea because the permeability of the clay soil was too low for leaching to occur.

Thus, deep placement of urea supergranules is not recommended in soils where high percolation is anticipated. This experiment points to the need for evaluating and reporting the percolation rates in soils where experiments with deep-placed supergranular urea are conducted.

In another greenhouse experiment, a variety of conventional and experimental fertilizers were used for rice grown in two soils subjected to continuous or intermittent flooding. Experimental results demonstrated a dramatic increase in fertilizer nitrogen recovery by the plant when deep placement and controlled release were combined. The mean apparent recovery of fertilizer nitrogen by the deep-placed sulfur-coated urea supergranule was 84% compared with only 48% for split applications of prilled urea.

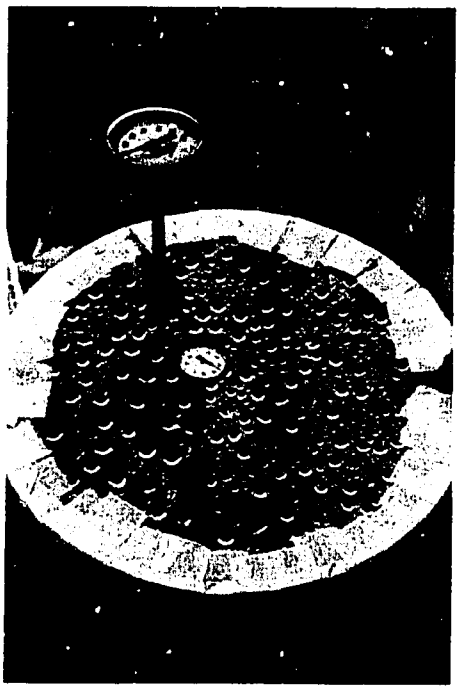
Data from the experiment suggest that ammonia volatilization was a major cause of nitrogen loss in the experiment. Other greenhouse and growth chamber research has pointed to the contribution of ammonia volatilization as a cause of nitrogen loss, particularly from broadcast urea. Use of modified urea products such as sulfur-coated urea (SCU) and urea supergranules placed in the reduced soil zone effectively reduced this loss in greenhouse trials. In these tests, leaching losses could not occur.

The poor performance of surface-applied prilled urea—the prevailing practice of most rice farmers—points to the urgency of introducing more effective nitrogen fertilizer practices and materials to developing countries.

Sources of Experimental Materials

Many of the experimental products being studied in the nitrogen efficiency program were prepared by IFDC in laboratory scale equipment. Forestry grade urea is available commercially in limited quantities, while 1 g or larger supergranules are not. For these studies IFDC arranged through private companies for the procurement of small quantities of supergranules which were produced in a pilot plant. The supergranules can be of various types—granules, briquettes, or tablets. The granular form is preferred since the surface and shape is more conducive for coating application (round and smooth).

Laboratory equipment for coating consisted of a rotary drum fitted with internal flights and deflective pan; this is the basic design of the coating drum used in the TVA sulfur-coated urea process. Facilities are available for using a wide variety of coating materials such as sulfur, waxes, synthetic polymers, inorganic salts, and etc. The TVA-developed coating consisting of sulfur,

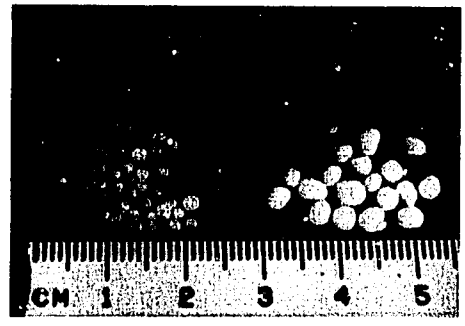


Research on the magnitude and pathways of nitrogen loss including volatilization is being carried out at IFDC Headquarters.

sealant, and conditioner also can be used. IFDC's intent is based on three reasons primarily: (1) to acheive release patterns more nearly approaching the crop requirements, (2) to use locally available materials, and (3) to achieve controlled dissolution of particles that can be deep placed. Probably no one single product or management practice will suffice to achieve improved efficiency; therefore, IFDC is studying various alternatives that may be utilized depending on the specific situation.

Production technology of the substrate such as supergranules and briquettes needs more attention. Tests by IFDC in a 1-tph pilot plant using a modified rotary drum indicated that 1-3 g urea supergranules can be made. However, certain technical problems were identified such as particle breakage in the cooling, transport, and screening equipment. IFDC intends to determine the technical and economic feasibility for production of supergranules through an enlarged pilot scale program next year. In addition to the rotary drum initially used, tests will be made with a pan-type granulator. Plant requirements will be defined whereby a variety of particle sizes could be produced either simultaneously or intermittently in a urea granulation plant. This will represent a significant increase in research toward increasing nitrogen utilization efficiency through modified forms of urea.

In a limited way, IFDC initiated a program to survey the potential of non-urea nitrogen materials. A literature survey was begun to update information (technical and agronomic) on such materials as oxamide, buiret, triuret, and urea-aldehyde condensation products. Small quantities are being produced or procured for screening with rice as the test crop in the IFDC greenhouse next year. The literature survey will cover the period, 1962-1976. When completed, it will be available as a technical bulletin.



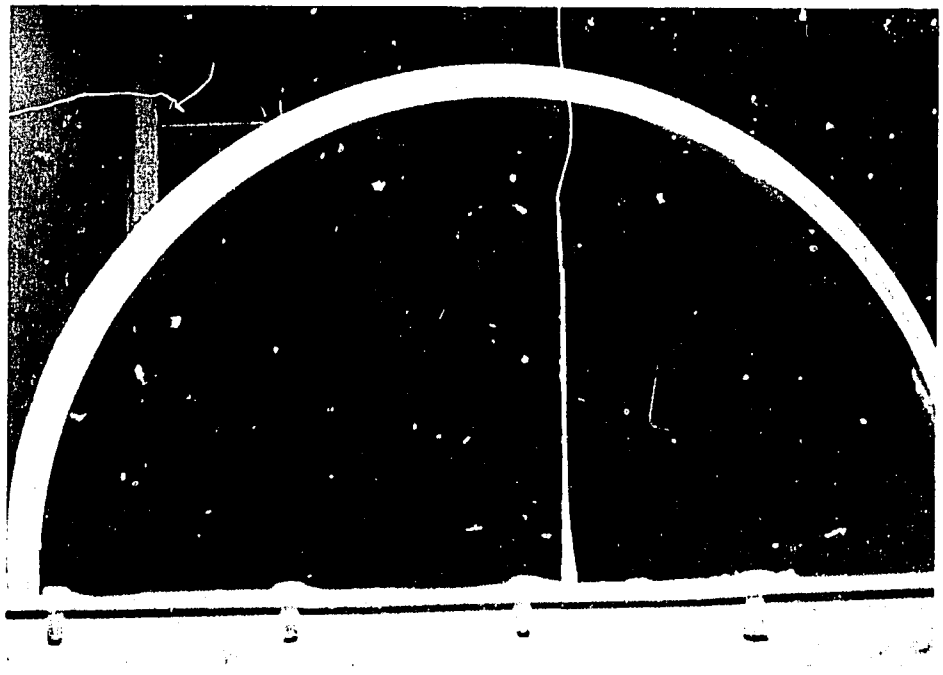
Granular and prilled urea (upper) and SCU—regular, forestry grade, and 1-, 2-, 3-, and 8-g supergranules—(lower) are examples of experimental fertilizers being studied at IFDC.

Experimental quantities of coated nitrogen fertilizers such as urea are being prepared in the laboratory for agronomic testing in greenhouse and field plots overseas.

Phosphorus Program

The total world phosphate reserves and resources is equivalent to at least 144,000 million mt of reasonably high-grade phosphate rock. These reserves and resources should be sufficient to supply the world's needs for more than 400 years at a rate of 300 million mt per year, a rate that has been projected for the year 2000. But a large percentage of the world phosphate resources is located in areas of low agricultural potential such as north Africa and west Asia. Other areas of high agricultural potential such as southern and southeastern Asia from Pakistan to Indonesia are lacking in adequate phosphate deposits.

Although there is a surplus supply of phosphate rock on the world market at present and world reserves of reasonably high-grade rock are adequate for the foreseeable future, developing countries need to discover and develop indigenous deposits for several reasons. First is the natural desire to be independent of foreign sources which may manipulate supply and price. Second is the prospective savings in foreign exchange and increased domestic employment. Third, important savings in ocean and inland freight costs are possible, especially for inland countries or inland regions of large countries, if the indigenous deposits are located in potential consuming areas. For these reasons, indigenous deposits are important to the agricultural development of many countries. Even small deposits may be locally important in those areas where soils are deficient in phosphorus and the need for increased food production is great.



Pilot-plant tests were initiated in 1978, with research being expanded in 1979.

Greenhouse experiments are a vital part of IFDC's phosphorus program.

Focus of Phosphorus Research

IFDC's phosphorus research program is aimed primarily at developing better and cheaper forms of phosphate fertilizers for tropical soils, using indigenous resources where appropriate. Some ores can be used with relatively little processing, while other "difficult ores" (ores that are usually high in silica, iron, aluminum, chloride, or free carbonates) require more elaborate processing. Most developing countries do not have the appropriate technology for processing difficult ores, and in most cases the technology is either uneconomical or does not exist.

The IFDC phosphorus program includes a systematic procedure for evaluating the best technical uses for a given deposit while keeping in mind the constraints of each situation. The technical alternatives include benefication through chemical processing (upgrading or concentrating the phosphate minerals), direct application, and modification (conversion to thermal phosphates, partially acidulated products, and fully acidulated products) of deposits.

Direct application of phosphate rock is being evaluated for developing countries because it is not a sophisticated technology and is not capital or energy

intensive, thus being a relatively low-cost phosphate fertilizer. Direct application may be a good alternative in many tropical and subtropical agricultural situations, but it is not necessarily applicable to all climate, soil, and plant situations.

Some situations require that the phosphate be present in a form that is more available to plants than is in the rock itself, especially to achieve a high initial response. One type of material that has this property is the thermal phosphates, which are also under study at IFDC. These materials are prepared by reacting phosphate rock with various reagents at an elevated temperature to produce a more available form of phosphate. These materials can be prepared from ores that are not physically or chemically suited for conversion to chemical fertilizers by conventional methods. Thermal phosphates of various types are produced commercially; IFDC is evaluating various ore types in these processes.

Partially acidulated phosphate rock is prepared from rock that is not well suited for direct application due to low reactivity for use in cases where a mixture of water-soluble and water-insoluble phosphate is desired. Fully acidulated products include superphosphates, nitrophosphates, and phosphoric acid. IFDC is evaluating various ore types from developing countries to determine their suitability for use in these conventional processes. Thus, IFDC has attempted to establish a comprehensive program to fulfill the overall objective.

Characterization

Phosphate rock used in IFDC's research program is completely characterized, including chemical, mineralogical, and particle-size analysis, to determine the composition and properties of the starting materials. Characterization enables IFDC researchers to define potential methods for using the ore and problems that may be encountered. It identifies the kinds and amounts of materials present, their particle-size relationships, crystallinity, and reactivity.

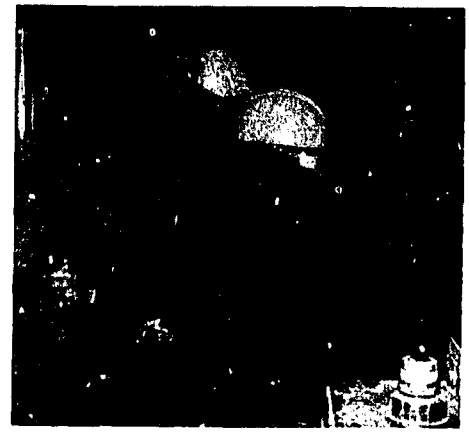
During 1978, IFDC, with support of the Tennessee Valley Authority (TVA), conducted 11 detailed characterization studies on phosphate rock from the Philippines, Chile, India, Syria, Brazil, Thailand, and Mexico.

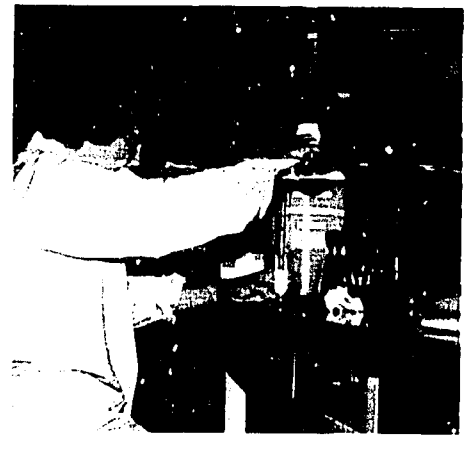
Work done for the Philippine government is one example of how this information is used to determine the best use of a particular deposit. A cooperative agreement was entered into with The Philippine Council for Agriculture and Resources Research (PCARR). IFDC researchers together with a scientist from the University of the Philippines at Los Banos (UPLB) conducted mineralogical and chemical analysis of samples from the guano-derived indigenous phosphate deposits of the Philippines and prepared experimental quantities of products to evaluate their potential as phosphate fertilizers. Samples were either calcined at relatively low temperatures or partially acidulated with phosphoric acid.

Agronomic tests using these nutrients are underway in the greenhouse at the UPLB under the PCARR agreement. Based on the results of these greenhouse experiments, field tests will be conducted at three Philippine locations where phosphorus-deficient soils cover extensive agricultural areas and where guano-derived phosphate deposits are accessible. If the products from calcination or partial acidulation prove promising in field tests, additional rock samples will be sent to IFDC for such processing.

Beneficiation of Siliceous Ores

Phosphate rock that is high in silica is an example of a difficult ore receiving attention at IFDC and one which is available in several developing countries. As much as 50% of the P_2O_5 may be lost when the ore is beneficiated. During 1978, IFDC researchers conducted laboratory scale beneficiation studies on three phosphate rocks—Pesca, Colombia; Kodjari, Upper Volta; and Vernal, Utah, United States—in an attempt to maximize grade and minimize losses. Research was conducted to develop special techniques





After experimental products are produced (upper), they are evaluated under simulated tropical conditions in the soil chemistry laboratory to correlate research results with greenhouse and field data (lower).

and expertise for upgrading these siliceous-type phosphate rocks. This research will serve as a basis for initial pilot-plant equipment operation and training next year.

Direct Application of Rock

During 1978, IFDC researchers continued their efforts to develop methods for improving the handling and agronomic properties of phosphate rock for direct application. Approximately 16 mt of research materials (285 samples) were produced for agronomic evaluation in IFDC's soils laboratory and greenhouse, in tests plots at the International Center for Tropical Agriculture (CIAT) in Colombia, TVA forest fertilization research program, the University of Hawaii Benchmark Soils Project, and the UPLB.

As part of the direct application project, IFDC researchers have developed methods for granulating ground phosphate rock with a small amount of binder (about 3%), with other fertilizer materials, or with a relatively small amount of sulfuric acid or phosphoric acid (20% acidulation). Test results indicate that the use of acid binders (partial acidulation) not only promotes granulation but also converts some phosphates in the rock to a more available form. Greenhouse tests indicate that using only 20% of the phosphoric acid required for total acidulation gives a product that behaves comparable to TSP. Thus, partial acidulation offers good potential for increasing the agronomic suitability of less reactive rock with a low level of use of acid. Partial acidulation may also allow minigranulation to be carried out without the need for a energy costly drying step; the reaction of rock with acid removes free water because of the heat generated.

Research has shown that the effectiveness of granulated ground phosphate rock decreases as the particle size increases. A particle size of 6- to 16-mesh (1.0-3.3 mm) which is a common size for granular fertilizer, results in poor effectiveness for phosphate rock, at least for the initial response. IFDC is studying a minigranulation process to produce small granules (0.1-0.3 mm, for example) which are dust free but agronomically effective. The initial product had been previously ground to 150-mesh (0.05 mm) or smaller. Technical, economic, and agronomic factors of phosphate rock products will continue to receive considerable attention in 1979.

Thermal Treatment

Phosphate ore that is high in silica, iron and aluminum, chlorine, or carbonate is often difficult to use. IFDC researchers conducted laboratory tests to chemically and thermally alter these ores to make them more useful. Although thermal phosphates require energy intensive processing and are often lower than water-soluble materials in terms of P_2O_5 content, they may offer certain cost advantages by allowing difficult phosphate ores to be utilized. In addition, the controlled-release characteristics and retained contents of secondary- and micro-nutrients of thermal phosphates may enhance their usefulness for some tropical areas. Small quantities of thermal phosphate materials were made for greenhouse testing at IFDC in 1978.

Phosphoric Acid Production

The behavior of different rocks in phosphoric acid production normally cannot be predicted from characterization alone. Each rock must be tested to determine its suitability for making phosphoric acid. IFDC researchers conducted bench-scale studies on two difficult phosphate rocks—Pesca, Colombia and Hazara, Pakistan—as well as on a concentrate of Araxa, Brazil to test their suitability for phosphoric acid production. Pilot-plant tests are planned for next year when the facility will be ready for initial operation.

Bench-scale phosphoric acid studies were in a conventional process and clinker process made using unbeneficiated ores and/or concentrates. Interest in direct acidulation of unbeneficiated ore is due to a potential overall higher P_2O_5 recovery, since beneficiation losses are not encountered.

As an alternative to the conventional wet-process phosphoric acid methods, IFDC researchers are testing the so-called "clinker" process in which the ore is treated with strong (93%-100%) sulfuric acid, and the acidulated mass is subsequently extracted to produce a 50^+% P_2O_5 phosphoric acid. The potential advantages of such processes are that strong phosphoric acid might be obtained directly without evaporation and unbeneficiated ores may be used. During 1978, IFDC researchers evaluated the effectiveness of this process in treating the siliceous phosphate ore Pesca, Colombia. The researchers designed and constructed a batch-type bench-scale unit and collected such preliminary data as P_2O_5 recoveries, quality of the product acid, clinker characteristics, and clinker stability. Studies with siliceous ores from Upper Volta and Pakistan will be conducted next year.

Other Nutrient Programs

Because many tropical soils contain only minimal reserves of sulfur, the importance of chemical fertilizers as a source of plant nutrient sulfur is expected to grow during the coming years. Signs of sulfur deficiencies are being reported with increasing frequency in many developing countries, particularly in tropical areas. These deficiencies can be attributed in part to the increasing use of high-analysis fertilizers that do not contain sulfur.

Little research has been done on sulfur by IFDC in comparison with that done on nitrogen and phosphorus. Based on the need for research to better understand sulfur deficiencies and to improve its use as a fertilizer nutrient, IFDC researchers initiated studies to evaluate the extent of sulfur deficiencies and to provide fertilizer solutions, wherever feasible, based on indigenous raw materials.

IFDC in cooperation with The Sulphur Institute sponsored a workshop—"Sulfur Problems in the Tropics"—at Headquarters in late 1978. Nine agronomists and soil scientists from different areas of the world discussed various topics pertaining to sulfur.

IFDC will initiate other nutrient studies involving potassium, calcium, magnesium, and selected minor elements. Work on potash will begin in 1979 with the assistance from the Potash & Phosphate Institute of North America.

Collaborative Research Programs

A cornerstone of IFDC's research and development program is the development of more cost efficient fertilizers tailored for specific end uses. The ultimate determinant of success in achieving this objective is farmer acceptance and use of these newly devised materials and methods. Obviously, the agronomic performance and benefits of these materials and methods must be ascertained before wide-scale application can be accomplished.

While chemical analyses and greenhouse tests can be used effectively to screen the properties and performance of new materials and methods at IFDC's Headquarter facilities, testing under actual field conditions is a necessary prerequisite for determining the potential feasibility of newly developed products. IFDC has engaged the cooperation of a broad spectrum of research organizations and universities with the capability of conducting both benchmark and more extensive field tests of potentially attractive new fertilizers for developing countries.

Among the organizations engaged in testing IFDC's experimental fertilizers are the International Rice Research Institute (Philippines), International Center for Tropical Agriculture (Colombia), Food and Agriculture Organization of the United Nations, International Institute of Tropical Agriculture (Nigeria), Indian Council of Agricultural Research, Indian Agricultural Research Institute, West Africa Rice Development Association, and Bangladesh Agricultural Research Council.

Field tests conducted at CIAT (upper) and IRRI (lower) are essential to IFDC's research and development program.

International Center for Tropical Agriculture (CIAT)

Two IFDC soil scientists are stationed at CIAT in Cali, Colombia, as part of a collaborative research project between IFDC and CIAT, supported by IDRC. The overall objective of the IFDC-CIAT project is to develop a phosphorus management strategy for the various crops and cropping systems in Latin America. Greenhouse studies are designed primarily to screen low-cost phosphate fertilizers. Field experiments are conducted to determine if these promising materials are in fact adaptable for farmer use.

This research is currently at the stage of setting up a network of integrated laboratory, greenhouse, and field experiments on acid soils of subtropical and tropical Latin America, with primary emphasis on phosphate fertilizers.

During 1978, the laboratory work consisted of characterization studies of soils and the many phosphate rocks. In addition, the laboratory was used for continuous monitoring of on-going greenhouse and field experiments.

To date, 16 field experiments have been established with several crops on representative sites throughout Colombia and at the Pucallpa Experimental Station in Peru. Several additional field experiments will be established in cooperation with national institutes in Brazil, Colombia, Peru, and Venezuela. Green-

house and laboratory studies are underway to identify promising phosphate materials for field testing at these sites.

Favorable results were reported in a field test at CIAT where more reactive phosphate rock—North Carolina, United States; Gafsa, Tunisia; and Sechura, Peru—were as much as 90% as effective as triple superphosphate (TSP) for the bean crop and superior to TSP for a series of three bean crops. In a test with cassava, a long-season crop, all phosphate rocks gave good responses; higher effectiveness was found with low-reactivity rocks on long-term crops compared with short-term crops.

International Rice Research Institute (IRRI)

As part of another collaborative research project, an IFDC soil scientist is working at IRRI, in the Philippines. The objective of this cooperative research is to identify loss mechanisms of nitrogen and to develop and help introduce more effective nitrogen fertilizer materials and management practices for lowland rice-growing areas.

During 1978, basic field studies were conducted at IRRI to identify the transformation and utilization processes that affect nitrogen recovery by rice under Asian field conditions where the crop is grown. IFDC and IRRI researchers evaluated the effectiveness of SCU, urea supergranules, and sulfur-coated urea supergranules on rice.

The International Network for Fertilizer Efficiency for Rice (INSFER) is also involved with this research. Extensive experimental testing of IFDC-produced urea supergranules, TVA produced SCU, and locally made mudballs began in 1975 by INSFER, a network of scientists from developing countries being supported by IRRI and IFDC.

From 1975-77, a total of 84 experiments in India, Bangladesh, Sri Lanka, Thailand, Malaysia, Indonesia, and the Philippines showed that SCU, supergranules, and mudballs consistently produced better rice yields than the best conventional fertilizer management practices such as split urea applications. In some experiments, placement and controlled release showed spectacular yield advantages over split doses of urea. From the data available to date, however, the soil, climatic, and crop managment combination for which a particular fertilizer and management practice should be used cannot be clearly identified.

IRRI and IFDC scientists and economists concluded that nitrogen recovery can be enhanced by 10% to 30% and yield increases from 5% to 300% are possible from the use of these materials, depending upon the original level of soil fertility and crop management. Surface-applied SCU and deep-placed supergranules consistently gave yield increases of 500 kg or more of rice per hectare with the same or lesser amounts of conventional urea nitrogen applied even when the rice crop is grown under the best management practices. In some cases, the same or higher yields are achieved with 20% less nitrogen supplied as SCU or as supergranules. Work is continuing in this area.

A training program was initiated for junior staff members who are conducting INSFER experiments throughout Asia.

Institute of Agricultural Sciences (IAS)

As part of a cooperative agreement, IFDC and IAS researchers conducted five field experiments in Korea to determine the effect of controlled-release fertilizers and fertilizer management practices on flooded rice.

They used two rice varieties on continuous and intermittent flooded fields with regular urea and two sulfur-coated ureas applied at either four or five different levels of nitrogen. Results indicated that nitrogen uptake during the period of 2 weeks after transplanting to maximum tillering most critically influenced potential yield.

Korean Institute of Science and Technology (KIST)

IFDC and KIST conducted cooperative research to develop a controlled-release fertilizer based on coating of urea. The research is an attempt to obtain nutrient release characteristics that more closely match the needs of rice varieties common to Korea and to other Asian countries.

During 1978, IFDC provided KIST with experimental quantities of urea in the form of forestry grade (4-6 mm diameter) and 1-g supergranules (12 mm diameter) as substrate for use in the coating work. One of the more promising controlled dissolution products is a silicate-acrylic latex-coated urea made in the laboratory using a fluidized bed. A preliminary economic estimate of the process is being made, and the products will be fully tested in greenhouse and field plots in 1979.

University of Hawaii Benchmark Soils Project (BSP)

IFDC and BSP initiated a collaborative research project to evaluate the effectiveness of alternative phosphate fertilizer materials, including ground phosphate rock and phosphate rock modified by particial acidulation and minigranulation. The relative efficiency of these sources will depend on such factors as source properties, soil properties, and the crop management system. Each factor will be closely monitored to determine interaction. This type of basic agronomic information is essential for planning phosphorus fertilizer strategies to benefit farmers with limited capital.

The five benchmark sites which will be used are located at Luzon and Mindanao, The Philippines; Java and Sumatra, Indonesia; and Hawaii, United States.

Fertilizer Corporation of India (FCI)

Full farm-level evaluation of new fertilizer materials or of innovative fertilizer practices is needed in order that policy decisions affecting the small farmer are made on the basis of sound economic and agronomic data. Field evaluation is a slow and often difficult path, particularly where farm sizes of less than 1 ha and field sizes of less than a quarter of a hectare are common. FCI in cooperation with IFDC is assessing the value of modified urea products. Field response data developed by FCI has proved invaluable to IFDC.

Determining the fertilizer technology needs of the people in developing countries is fundamental to IFDC's technical assistance program.

TECHNICAL ASSISTANCE AND MARKET DEVELOPMENT

To achieve its goal of increasing agricultural productivity in developing countries, IFDC must make available and, where appropriate, transfer technical information and technology on fertilizer production, marketing, and use to developing countries. IFDC also must assist national and international agricultural development organizations by providing needed technical backstopping to their programs.

Highlights of IFDC's technical and market development assistance programs during 1978 follow.

Africa

Madagascar

At the request of the Overseas Private Investment Corporation, IFDC researchers conducted an economic study of a Madagascar ammonia/urea project. The purpose of the study was to determine the economic viability of an ammonia/urea plant as an alternative nitrogen fertilizer supply source relative to importation.

Nigeria

At the request of The World Bank, IFDC researchers carried out a study to assess the agronomic and economic suitability of urea as a source of nitrogen on low-base soils in Nigeria. The researchers concluded that urea, or NPK fertilizer containing urea can easily be incorporated into soil during the seedbed preparation, and incorporated as urea topdressing at the time of weeding with little change in recommended cultural practices. Recommended products to supply nutrient requirements were urea, monoammonium phosphate, urea-ammonium phosphate with and without potassium, and partially acidulated phosphate rock containing sulfur.

Senegal

IFDC researchers served as consultants to the Societe de Developpement et de Vulgarisation Agricole (SODEVA) of the Senegal government to study the response of millet and groundnut to N, P, and K. The researchers assisted SODEVA in planning, conducting, and interpreting field trials conducted in farmers' fields to verify data to be used at the farm level.

Asia

Bangladesh

Two major projects were begun in Bangladesh in 1978. One consisted of a collaborative research project aimed at identifing the principal constraints to fertilizer adoption and demand and developing appropriate public policies to help relax these constraints. This project is a joint Bangladesh Agricultural Research Council (BARC) and IFDC effort. The farm-level survey is being carried out in four regions of Bangladesh, and the data will be analyzed at BARC and IFDC.

The second major project in Bangladesh involved IFDC researchers visiting Bangladesh to gain information necessary to appraise the Bangladesh fertilizer sector, to identify constraints to increased fertilizer use, and to suggest remedial action. The findings and recommendations of the IFDC in-country study were presented in Technical Bulletin IFDC T-11. This publication appraises the conditions and problems of the Bangladesh fertilizer sector and offers suggestions for remedial action.

Central and Latin America

Bolivia

At the request of USAID/Bolivia, IFDC studied the technical feasibility of installing a bulk-blending and bagging plant to provide fertilizers to the small-farm sector at lower prices. A report was prepared with a number of conclusions and recommendations and sent to USAID/Bolivia. The solution to the Bolivian fertilizer problem centered around a six-phase program that moves from the import of bagged materials into a mixed system of bulk handling, blending, and bagging with the future incorporation of indigenously produced fertilizers.

Brazil

An IFDC engineer and a TVA engineer provided consultative assistance to Companhia Riograndense de Adubos (CRA) for the startup of their MAP granulation plant in Rio Grande, R.S., Brazil.

IFDC conducts in-country studies to determine farming and fertilizer practices in developing countries.

Caribbean Basin Study

IFDC researchers developed profiles for 20 countries located around the Caribbean Basin to identify the constraints on fertilizer production, supply, and use in the area.

The role of fertilizer as an input to agriculture and its potential contribution to increased food production was evaluated. Ways to expand fertilizer use to its full potential were explored in collaboration with organizations within the Caribbean Basin. A report will be published.

Colombia

IFDC researchers provided technical assistance to Monomeros Colombo Venezolanos, S.A. (MONOMEROS) of Barranquilla, Colombia by advising on improvements and expansion of port and unloading facilities. Researchers also assisted MONOMEROS in finding ways to utilize a local phosphate deposit for fertilizer production in their existing plants.

TRAINING

The training of manpower needed in developing countries to produce and market fertilizer is fundamental to IFDC's mission. During 1978, approximately 275 participants from 25 developing countries were involved in IFDC training programs at Headquarters and in developing countries.

Highlights of IFDC's training program during 1978 follow.

A part of IFDC's 1978 training program was a followup seminar in Bangladesh.

Followup Seminars

In followup to an 11-month maintenance course at IFDC in 1976-77, IFDC staff members worked with eight Bangladesh Chemical Industries Corporation (BCIC) engineers on maintenance seminars at three operating fertilizer factories in Bangladesh. The maintenance seminars were designed to assist the engineers in conducting formalized training and development programs for BCIC employees.

Marketing and Distribution Course

A 6-week course on fertilizer marketing and distribution was conducted at IFDC Headquarters. Twenty-four participants from the Philippines, Indonesia, Malaysia, India, Nepal, Bangladesh, Jordan, Ethiopia, Colombia, and the Dominican Republic participated in the course. The course combined classroom instruction and visits to industry to demonstrate different techniques of transporting, handling, storing, and selling of fertilizers.

An important part of this annual course is the problem-solving approach where each participant is encouraged to identify and suggest a solution to problems that act as constraints to improved fertilizer distribution and marketing in his country or company.

Fertilizer Use in the Tropics

IFDC, in cooperation with the International Institute of Tropical Agriculture (IITA), conducted a 3-week training course on fertilizer use in the tropics. Twenty-five participants from 14 countries attended the course at IITA, Ibadan, Nigeria. The course was designed to benefit workers engaged in fertilizer use research for food crops. Topics of instruction ranged from soil fertility and testing to economics of fertilizer use at the farm level. One-half of the time was devoted to classroom instruction and the remainder to laboratory, greenhouse, and field practices designed to fortify the classroom sessions. Follow-up with the participants will continue in 1979 and 1980.

Training Evaluation

Evaluation of IFDC's training programs includes (1) the identification of training needs, (2) measurement of course impact on the knowledge and skill level of participants, and (3) followup regarding utilization of trainees on return to their home countries. Research was initiated in the second of these areas to evaluate the 1978 Fertilizer Marketing and Distribution Course. Both pre- and post-tests were prepared to measure participants' knowledge in three areas—fertilizer basics, nutrient content, and product identification. A post-test covered specific course-related subject matter relating to the distribution and marketing of fertilizers. Trainees having greater knowledge in the three referenced areas at the start of the course scored higher on the distribution and marketing post-test than did trainees who had only limited knowledge about fertilizers at the start of the course. These and other evaluation results are assisting in (1) assessing the effectiveness of the Fertilizer Marketing and Distribution Course in meeting its objectives and (2) identifying a range of areas in which the course can be improved.

Workshops and Study Groups

Nitrogen Fertilizer Workshop

Consultations between Indian and IFDC scientists, in collaboration with (and partial funding by) the Ford Foundation, resulted in the convening of a joint Nitrogen Fertilizer Workshop at IFDC Headquarters in 1978. Eight senior soil scientists and agronomists were selected by the Indian Council of Agricultural Research to participate with IFDC staff members in the workshop.

The workshop's overall aim was to develop appropriate fertilizer-use technology for different rice cultivation conditions prevailing in India and to collaborate in developing improved fertilizer materials for rice.

The workshop took the form of formal presentations by and broadly scoped, intensive discussions between the Indian participants and IFDC staff members on the varied aspects of rice fertilization practices in India and elsewhere. The status of nitrogen fertilization research was subjected to a detailed review. The Indian participants engaged with IFDC staff members in drafting tentative proposals to serve as a basis for further discussions on cooperative work between the Department of Agricultural Research and Education, Government of India and IFDC.

Technical Training

Nine professional staff members from the Centro de Estudos de Fertilizantes (CEFER), Sao Paulo, Brazil, spent 2 weeks at IFDC Headquarters studying different aspects of fertilizer research and development. Two members of the group stayed an additional 5 weeks for special study and experience. Subject presentations and discussions were combined with individual study with IFDC and TVA specialists.

Prior to this training program, IFDC conducted an intensive shortcourse in fertilizer granulation for the Brazilian fertilizer industry in Sao Paulo. About 10 of CEFER's staff, plus about 60 other participants representing a large portion of the fertilizer producers in Brazil, attended the shortcourse.

IFDC and IITA conducted a training course on fertilizer use in the tropics.

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205-328-8700

March 23, 1979

To the Board of Directors of

International Fertilizer Development Center

In our opinion, the accompanying balance sheets and the related statements of revenue and expenses and changes in fund balances and of functional expenses present fairly the financial position of International Fertilizer Development Center (IFDC) at December 31, 1978 and 1977, and the results of its operations and changes in fund balances for the years then ended in conformity with generally accepted accounting principles consistently applied. Our examinations of these statements were made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

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INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

BALANCE SHEETS

CURRENT FUND (unrestricted)

Assets

	December 31, 1978	December 31, 1977
Cash	$ 702,468	$ 675,986
Certificates of deposit	91,109	83,806
Accounts receivable from donors (Note 2)	3,103,898	4,806,048
Other accounts receivable	105,248	111,591
Advances to employees	18,360	19,594
Supplies inventory (Note 1)	42,646	
Prepaid expenses	44,120	95,165
	$4,107,849	$5,792,190

Liabilities and Fund Balances

	December 31, 1978	December 31, 1977
Accounts payable	$ 214,019	$ 337,005
Accrued annual and sick leave	317,286	184,480
Deferred revenue (Notes 1 and 2)	3,103,898	4,826,559
Total liabilities and deferred revenue	3,635,203	5,348,044
Fund balance	472,646	444,146
	$4,107,849	$5,792,190

PROPERTY AND EQUIPMENT FUND (Notes 1 and 4)

	1978	1977
Buildings	$5,577,896	$5,491,018
Equipment	2,949,737	1,276,033
Less - accumulated depreciation	(586,518)	(177,833)
	$7,941,115	$6,589,218

	1978	1977
Accounts payable	$ 55,474	$ 108,839
Contract retainage	21,079	36,699
Total liabilities	76,553	145,538
Fund balance	7,864,562	6,443,680
	$7,941,115	$6,589,218

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

STATEMENT OF REVENUE AND EXPENSES AND CHANGES IN FUND BALANCES

YEAR ENDED DECEMBER 31, 1978 WITH COMPARATIVE TOTALS FOR 1977

	1978		Total All Funds	
	Current Fund	Property and Equipment Fund	1978	1977
Revenue:				
Grants received (Note 2)	$5,806,531		$5,806,531	$6,138,639
Recovered project costs	254,265		254,265	160,015
Other	21,638		21,638	13,207
Total revenue	6,082,434		6,082,434	6,311,861
Expenses:				
Research	2,276,168	$ 307,117	2,583,285	1,605,230
Outreach	985,571	43,880	1,029,451	829,417
General and administrative	962,028	58,288	1,020,316	824,088
Total expenses	4,223,767	409,285	4,633,052	3,258,735
Excess (deficiency) of revenue over expenses	1,858,667	(409,285)	$1,449,382	$3,053,126
Other changes in fund balances:				
Property and equipment acquisitions from unrestricted funds	(1,830,167)	1,830,167		
Fund balances, beginning of period	444,146	6,443,680		
Fund balances, end of period	$ 472,646	$7,864,562		

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

STATEMENT OF FUNCTIONAL EXPENSES

YEAR ENDED DECEMBER 31, 1978 WITH COMPARATIVE TOTALS FOR 1977

	1978			Total Expenses	
	Research	Outreach	General and Administrative	1978	1977
Personnel compensation (Note 3)	$1,275,407	$ 538,010	$ 523,300	$2,336,717	$1,577,445
Personnel benefits (Note 3)	188,705	90,902	89,086	368,693	248,666
Travel and transportation	201,865	163,367	70,082	435,314	360,376
Occupancy (Note 4)	110,134	43,056	44,059	197,249	155,736
Telephone and telegraph	52,426	28,281	39,335	120,042	85,530
Rental of equipment	27,360	30,122	18,746	76,228	127,112
Contractual research and development	71,770	4,185		75,955	78,559
Other contractual services	143,421	44,284	41,557	229,262	187,172
Institute of International Education fee (Note 3)			64,950	64,950	43,700
Materials and supplies	205,080	43,364	31,446	279,890	174,749
Postage			7,863	7,863	11,406
Insurance			31,604	31,604	10,890
Miscellaneous	72			72	22,646
Total expenses before depreciation and amortization	2,276,240	985,571	962,028	4,223,839	3,083,987
Depreciation of furniture and equipment and amortization of leasehold improvements	307,045	43,880	58,288	409,213	174,748
Total expenses	$2,583,285	$1,029,451	$1,020,316	$4,633,052	$3,258,735

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

NOTES TO THE FINANCIAL STATEMENTS

NOTE 1 - ORGANIZATION AND ACCOUNTING POLICIES -

The International Fertilizer Development Center (IFDC) is a non-profit organization incorporated October 7, 1974 under the state laws of Alabama. On March 14, 1977, IFDC was designated as a public international organization by executive order of the President of the United States. The purpose of the organization is to improve fertilizers and fertilizer know-how in developing countries through research and development, technical assistance and training and communications.

In the event of dissolution, the articles of incorporation provide that the residual assets of the organization will be turned over to one or more tax exempt organizations or to the federal, state or local government for exclusive public purpose.

The following is a summary of significant accounting policies.

A. Property and equipment is stated at cost. Depreciation and amortization is computed on the straight-line method over estimated useful lives ranging from three to thirty years.

B. Revenue and expenses are accounted for on an accrual basis. In particular, grants of the United States Agency for International Development (AID) are recorded as receivable for the full amount at the date of the grant. Amounts not clearly designated for a specified program period are deferred in the balance sheet and reflected in revenue when received. Contributions for reimbursable costs are recognized as project costs are incurred.

   Revenue is restricted only to the extent it is to be used in accordance with the purpose of the organization unless otherwise indicated.

C. Inventories of supplies are valued at the lower of cost or replacement cost, cost being determined on a first-in, first-out basis.

NOTE 2 - GRANTS -

Grants received are summarized as follows:

	Year ended December 31, 1978	1977
United States Agency for International Development (AID)	$4,000,000	$ 5,700,000
International Development Research Center (IDRC)		310,175
Rockefeller Foundation	11,870	20,511
Israel Chemicals Limited	50,000	50,000
Fertilizer and Pesticide Authority of the Phillipines	10,000	10,000
Espindesa	12,000	
	4,083,870	6,090,686
Amounts deferred during prior year	4,826,559	4,874,512
	8,910,429	10,965,198
Less - Amounts deferred to future periods	(3,103,898)	(4,826,559)
Revenue recognized in current period	$5,806,531	$ 6,138,639

The current grant from AID was amended to provide additional funds of $4,000,000 and $5,700,000 during the years ended December 31, 1978 and 1977, respectively, and to extend the grant period from December 31, 1978 to June 30, 1979. The amounts of $3,070,249 and $4,645,249 had not been received at December 31, 1978 and 1977, respectively, and were not clearly designated for a specified program period and, accordingly, were deferred. The current amendment to the grant provides funds for basic core/operating costs. The use of funds by area is unrestricted except that equipment purchases may not exceed $3,022,000. Funds not legally committed at the grant expiration date will revert to AID.

The amount of $11,870 from the Rockefeller Foundation grant and the amount of $21,779 from the International Development Research Center grant were deferred at December 31, 1978.

NOTE 3 - INSTITUTE OF INTERNATIONAL EDUCATION:

IFDC has a contract with the Institute of International Education (IIE) relating to the employment of personnel of IFDC. All payroll administrative functions are performed by IIE; IFDC makes advances quarterly to fund salaries, employment taxes and fringe benefits.

NOTE 4 - FACILITIES:

Prior to the completion of the building facilities funded by a grant from AID, the buildings used for research and development and outreach programs and administrative office space were leased. The building used for the research and development and outreach programs was leased at an annual rate of $2,900. Administrative office space and additional space for outreach programs were leased on a month-to-month basis, rental expense was $13,100 for the year ended December 31, 1977.

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As of December 31, 1978
*Left during 1978.

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