

Phosphorus Research—

Thermal-Treated Phosphates

The use of indigenous phosphate ore deposits is often difficult because they have unusual compositions. IFDC Chemical Engineer A. H. Roy is conducting laboratory tests to determine how these phosphate ore types—high in silica, iron and aluminum, chlorine, or carbonate—can be processed to permit economical use. One possibility is a chemically thermally altered phosphate having varying degrees of availability.

Although thermal phosphates require energy-intensive processing and contain less P_2O_5 than modern water-soluble materials, they may provide a way to use rocks with low grade, low reactivity, and unusual composition. The slow-release characteristics and retained contents of secondary and micronutrients may enhance the usefulness of thermal phosphates for some tropical areas.

Dr. Roy is now studying some of the factors that influence the production of Rhenania-type phosphates—the effect of kiln temperature, inclination, and rotational speed (rpm) on the residence time, effect of temperature and residence time

on P_2O_5 availability of the product, and physical characteristics of feed and product.

Experiments were conducted to establish conditions which would cause a mixture of North Carolina phosphate rock, soda ash, and silica to react in a rotary kiln at temperatures ranging between 1000°C and 1200°C to yield Rhenania phosphate with a high percentage of available P_2O_5 . Direct treatment of physically mixed powdered feed had poor handling properties, and the product was low in available P_2O_5 due to incomplete reaction resulting from inadequate contact between phosphate rock and reagents. The feed was then granulated with water and subsequently calcined to obtain a product with high levels of available P_2O_5 .

Statistical analysis of the test results indicate that residence time in the kiln is independent of the temperature. However, the residence time is significantly and almost exclusively influenced by inclination and rotational speed of the kiln. The P_2O_5 availability in the product is



A. H. Roy is in charge of IFDC's laboratory testing program to economically use difficult phosphate ores.

significantly influenced by residence time and temperature in the kiln. Studies with rocks from Israel, Morocco, Tunisia, Peru, and Brazil are underway to correlate the composition of rocks to both energy requirement and sodium carbonate consumption for Rhenania phosphate-type products. Studies of other types of thermal treated phosphates will be made in future experiments.

N, P, K Study—

Millet and Groundnut Research in Senegal

Food production in the western African country of Senegal has not increased significantly since 1960. Average yields of millet, the staple food of the rural population, are about 500 kg/ha under the presently used low technology. Increased use of fertilizers is one of the surest methods of rapidly increasing food production in Senegal.

Agronomists from IFDC and the Societe de Developpement et de Vulgarisation Agricole (SODEVA) of the Senegal Government have shown that if fertilizer use is increased by only 20%, an additional 81,000 metric tons of millet could be produced.

IFDC Agronomists H. R. Tejeda and R. B. Diamond served as consultants to

SODEVA to study the response of millet and groundnut to N, P, and K. Fertilizer trials were conducted in farmers' fields in 1976 and 1977. Yields were measured. Location variables possibly affecting yield and response to fertilizer also were measured.

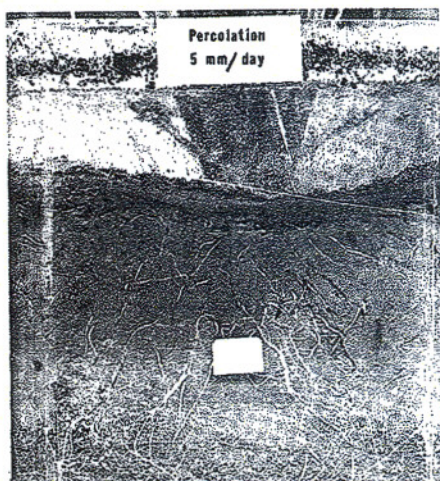
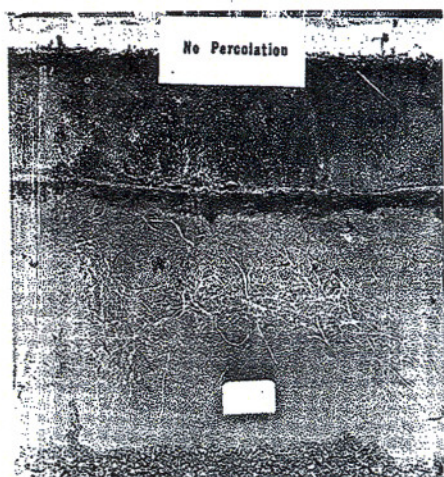
For millet the study showed that rainfall during the growing season, plant density, and soil phosphorus levels were the main location variables affecting millet yield and response to N and P. Little or no response to K was found. Optimum nutrient levels were 35 kg of N and 30 kg of P_2O_5 /ha at 500 mm of rainfall and 55 kg of N and 15 kg of P_2O_5 at 175 mm of rainfall. These application rates gave grain responses valued at three to five

times the cost of fertilizer. One kg of N gave 6.5-8.5 kg of millet grain, and 1 kg of P_2O_5 gave 7.5-11 kg of grain.

For groundnut the study showed no response to N. Rainfall had the greatest effect upon yield. Other variables having a significant effect upon yield without fertilizer were seeding date, density, soil organic matter, pH, and native P and K levels of the soil. Responses to P or K were dependent upon total soil P or K. Optimum levels of P_2O_5 applications were 59 kg/ha at 730 mm rainfall and 5 kg/ha at 160 mm. Application of K was economical only with more than 500 mm of rainfall. Optimum application rates gave responses of 3 to 7 kg of groundnut per kg of P_2O_5 and were valued at 2.3 to 5.1 times the cost of fertilizer.

Urea Placement—

Leaching Losses of Nitrogen from Flooded Rice Soils



Root development in the vicinity of urea supergranules without (top) and with (bottom) percolation.

Ammonia volatilization and denitrification account for most of the loss of nitrogen fertilizer applied to rice. Deep placement of nitrogen fertilizer in the form of urea briquettes or supergranules can reduce this loss. Deep placement has proved superior to split application of urea in a series of coordinated experiments recently conducted in 10 Asian countries. On some sites, however, supergranules produced lower yields than split application. Other loss mechanisms such as leaching may have caused the supergranules to perform poorly on these sites.

IFDC Soil Scientists P.L.G. Vlek, B. H. Byrnes, and E. T. Craswell recently completed experiments to determine 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. Silt loam and clay soils were subjected to percolation rates ranging from 0 to 20 mm/day while planted in rice, and harvested after approximately 40 days of plant growth.

Experimental results indicate that moderate to high percolation through silt loam soil fertilized with deep-placed urea supergranules leads to significant fertilizer N losses and drastically decreases the fertilizer uptake by plants. Such losses were negligible with broadcast urea. The permeability of the clay soil was too low for any leaching to take place. Deep placement of urea supergranules is not recommended in soils where heavy perco-

lation is anticipated, particularly if the cation exchange capacity of the soil is low. This experiment points to the need for evaluating and reporting the percolation rates in soils where experiments with supergranular urea are conducted.

Sri Lanka—

Eppawala Phosphate Rock Study Underway

The Dienst Internationale Technische Hulp (DITH), Sri Lanka, and IFDC joint research project on the utilization of Eppawala phosphate rock is underway. The project is concerned with the technical evaluation of Eppawala rock and its use in the production of different types of conventional phosphate fertilizers.

G. H. McClellan, IFDC Geologist, traveled to Sri Lanka in January for onsite inspection of the Eppawala phosphate deposit. A shipment of Eppawala phosphate arrived in Muscle Shoals in April. The ore was crushed, blended, and sampled for mineralogical and chemical analysis. Initial phosphoric acid tests using uncalcined Eppawala phosphate began in June and will run through July.

Mr. N. Malalasekera, Chemical Engineer, State Mineral Development and Mining Corporation, Sri Lanka, arrived at IFDC Headquarters in June to take part in the production of experimental quantities of various phosphate fertilizers. Dr. S. L. Amarasinghe, Soil Scientist, Central Agricultural Research Institute, Sri Lanka, will arrive in August to help test the experimental fertilizers in IFDC laboratories and greenhouses.

IFDC-UNDP—

Research and Training in Fertilizer Technology and Utilization

The United Nations Development Programme (UNDP) and IFDC have entered into a cooperative agreement aimed at improving food production in less developed countries through fertilizer research and training. IFDC scientists will carry out, in collaboration with selected international and national agricultural research centers, studies on the efficiency of nitrogen and phosphorus fertilizers under different soil conditions. Research on phosphorus fertilization of acid tropical soils in Latin America will include work in Peru, Ecuador, Venezuela, and possibly other countries. Research on nitrogen requirements and losses for arid and semi-arid tropical and subtropical soils and crops will be carried out in

cooperation with ICRISAT and ICARDA.

IFDC staff members also will develop and implement an expanded training program aimed at increasing the availability and utilization of trained manpower in fertilizer production, distribution and marketing, and use. Custom-designed programs which provide individualized on-the-job experience and training also will be included.

W. D. Bishop, Director of IFDC's Agro-Economic Division, assisted by P.L.G. Vlek, Soil Scientist, will coordinate the research activities. D. H. Parish, Director of IFDC's Outreach Division, assisted by C. R. Amstrup, Training Coordinator, will coordinate the training activities.



G. H. McClellan and N. Malalasekera examine phosphoric acid from Eppawala phosphate.

Clinker Process for Siliceous Phosphate Ore

The IFDC phosphorus research program is oriented toward determining the best technical and economical treatment alternatives for a given indigenous deposit and includes a systematic evaluation procedure in which beneficiation is one component. In many cases, however, it is technically difficult or economically impossible to beneficiate the ore. One such example is the siliceous-cemented phosphate ore which often requires expensive grinding to free the phosphate from the silica. The differential hardness of phosphate and silica also creates a large quantity of fines, or slimes, that may be lost during usual concentration processes. Direct chemical treatment of such ores would eliminate the need for beneficiation and perhaps increase overall phosphate recovery.

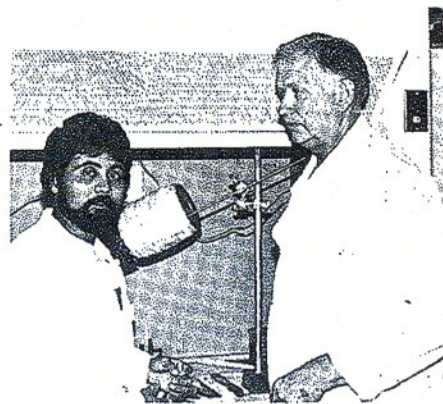
As an alternative to conventional wet-process phosphoric acid methods, A. H. Roy, Chemical Engineer, and V. L. Bulger, Laboratory Technician, are testing the so-called "clinker" process in which siliceous phosphate ore is treated with 93%-100% sulfuric acid. The acidulated mass is then extracted with water to produce a 50%+ P_2O_5 phosphoric acid. The advantage of the process is that

strong phosphoric acid might be obtained directly from unbeneficiated ores.

The ore selected for use in initial tests is from Pesca, Colombia. IFDC researchers designed and constructed a batch-type bench-scale unit to collect such preliminary data as P_2O_5 recoveries, quality of the product acid, clinker characteristics, and clinker stability.

Direct acidulation of phosphate ore gave a slimy reaction mixture, from which the phosphoric acid could not be extracted because adding water to the acidulated mass produced a slurry of non-filterable calcium sulfate and phosphoric acid. By calcining the reaction mixture to form clinkers, the phosphoric acid could be extracted.

Experimental setups of the clinker process involve a comparatively simple circuit with minimum equipment that will enable the scientists to make a feasibility study as well as a preliminary cost-benefit analysis. This process-variable study will thus provide enough background data to evaluate the process and to recommend if it should be continued at a larger scale. Statistical evaluation of the experimental data to date indicates that P_2O_5 extraction from the clinkers



A. H. Roy and V. L. Bulger are shown in front of experimental equipment used to make clinkers.

by water is favored by high-temperature leaching, short calcination time, low-temperature calcination, and the use of a slight excess of sulfuric acid over that required to react with the calcium in the ore. Although some disintegration of the clinker occurred during extraction, it was not excessive as long as P_2O_5 extraction from the ore did not exceed 75% to 80%. Studies with siliceous ores from Upper Volta and Pakistan are currently underway.

The Philippines—

Potential Phosphate Fertilizers

Developing indigenous phosphate deposits to increase food production and offset the drain of foreign exchange is important to both IFDC and developing countries. The Philippine Council for Agriculture and Resources Research (PCARR) with the responsibility of promoting a systematic approach in the planning, coordinating, directing, and conducting of the national agricultural research programs, developed a cooperative project in 1977 with IFDC to evaluate the guano-derived indigenous phosphate deposits of the Philippines as potential phosphate fertilizers.

The project consists of three phases: phase 1—collection of rock samples, phase 2—characterization-utilization studies, and phase 3—greenhouse and field tests. Collection of rock samples was funded by University of the Philippines at Los Banos and was carried out in 1978 in cooperation with the Department of Natural Resources (DNR). DNR mining engineers collected 400 samples from seven regions in the Philippines.

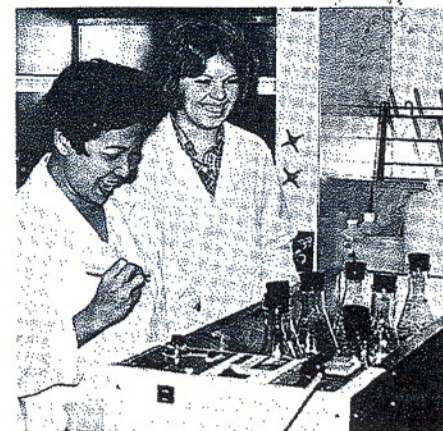
The characterization-utilization studies

were funded by IFDC and consisted of systematic chemical and mineral characterization of the guano-derived rock materials and simple laboratory tests for measuring and increasing their reactivities. Dr. Angelina M. Briones, Assistant Professor, Department of Soil Science, University of the Philippines at Los Banos, conducted mineralogical and chemical analysis on 25 of the samples at IFDC Headquarters.

Samples containing high amounts of iron and aluminum phosphates and having a low degree of solubility in neutral ammonium citrate solution were calcined at temperatures between 200°C and 700°C. The low temperature calcination resulted in a product with high amounts of citrate solubility which should be quite suitable as fertilizer. Similarly, samples with apatitic compositions and low citrate solubility were partially acidulated with phosphoric acid to increase their availability.

Greenhouse and field tests will be funded by PCARR. Based on the results of the greenhouse experiments, field tests

will be conducted in three locations where P-deficient soils cover extensive agricultural areas and where guano-derived phosphate deposits are accessible. If either of the products from calcination or partial acidulation prove promising in field tests, additional rock samples will be sent to IFDC for such processing.



Angelina M. Briones tests phosphate samples from the Philippines with Gail Jarnigan, IFDC laboratory technician.

Market Development—

Thailand Fertilizer Study

E. C. Kapusta, Regional Coordinator—Asia, and R. B. Diamond, Chief Coordinator—Market Development and Information Analysis Group, recently traveled to Thailand as members of a study team who are working to develop a fertilizer strategy for Thailand. The study is being conducted by IFDC in

cooperation with The World Bank and the National Committee on Fertilizer and Pesticide Industry Development (NCFPID) of Thailand.

The study involves the development of a short-term strategy for Thailand, on a prefeasibility basis, to assure that an adequate supply of appropriate fertilizer will

be available to Thai farmers, particularly the small farmer. Dr. Kapusta is working on the supply phase of the study, Dr. Diamond on the demand phase. Mr. Perry O. Onstot has been retained by The World Bank to participate in the fertilizer marketing and distribution segment of the study.

PUBLICATIONS AND REPRINTS AVAILABLE FROM IFDC

Reports

- "Sulfur in the Tropics," published by IFDC.
- "World Fertilizer Situation and Outlook—1978-85," published by IFDC and TVA.
- "Granular Urea—Advantages and Processes," published by IFDC.
- "The Potential for Regional Cooperation in Fertilizer—A Methodology Study of the ASEAN Group," published by IFDC.
- "Supplying Fertilizers for Zaire's Agricultural Development," published by TVA.
- "West Africa Fertilizer Study (Volumes I-VII)," published by IFDC.
 - Volume I—Regional Overview
 - Volume II—Senegal
 - Volume III—Mali
 - Volume IV—Upper Volta
 - Volume V—Niger
 - Volume VI—Chad
 - Volume VII—Mauritania
- "Economic and Technical Aspects of Fertilizer Production and Use in West Africa," T. Zalla, R. B. Diamond, and M. S. Mudahar, IFDC/MSU Working Paper No. 22, 1977.
- "Ghana—Progress in Fertilizer Production, Marketing, Education," published by TVA.
- "Suggested Fertilizer-Related Policies for Governments & International Agencies," published by IFDC.
- "Progress Report, 1976-1977," published by IFDC.
- "The Bangladesh Fertilizer Sector, 1978," published by IFDC.

Papers and Reprints

"A Comparison of Various Laboratory Methods for Predicting the Agronomic Potential of Phosphate Rocks for Direct Application,"

S. H. Chien and L. L. Hammond, *Soil Science Society of America Journal*, Vol. 42, No. 6, November-December 1978.

"Bench-Scale Studies of Utilization of Problem Rocks in Wet-Process Phosphoric Acid Production," A. Varsanyi, E. B. Winn, and P. H. Peng, Proceedings of ISMA Technical/Economic Conference, pp. 133-149, Orlando, Florida, October 23-27, 1978.

"Reactions of Phosphate Rocks, Rhenania Phosphate, and Superphosphate with an Acid Soil," S. H. Chien, *Soil Science Society of America Journal*, Vol. 42, No. 5, September-October 1978.

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"Fate of Fertilizer Nitrogen Applied to Wetland Rice," E. T. Craswell and P.L.G. Vlek, *Nitrogen and Rice*, Symposium proceedings, International Rice Research Institute, Manila, Philippines, 1978.

"Needed Information and Economic Analysis for Fertilizer Policy Formulation," M. S. Mudahar, Presented at FAO/IFDC Seminar on Fertilizer Pricing Policies and Subsidies, Bangkok, Thailand, 1978.

"A Simple Chemical Method for Evaluating the Agronomic Potential of Granulated Phosphate Rock," S. H. Chien and L. L. Hammond, *Soil Science Society of America Journal*, Vol. 42, No. 3, May-June 1978.

"Dissolution of Phosphate Rocks in Flooded Acid Soil," S. H. Chien, *Soil Science Society of America Journal*, Vol. 41, No. 6, Nov.-Dec. 1977.

"Interpretation of Bray I Extractable P from Acid Soil Treated with Phosphate Rocks," S. H. Chien, *Soil Science*, Vol. 126, No. 2, Aug. 1978.

"Thermodynamic Considerations of the Solubility of Phosphate Rock," S. H. Chien, *Soil Science*, Vol. 123, No. 2, 1977.

"Dissolution Rates of Phosphate Rocks," S. H. Chien, *Soil Science Society of America Journal*, Vol. 41, No. 3, May-June 1977.



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Barbara Holder
Communications Specialist

P.O. Box 2040
Muscle Shoals, AL 35660, USA
Phone No. (205) 381-6600
TWX-810-731-3970 IFDEC MCHL

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