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TVA's International
Fertilizer Programs

TVA'S INTERNATIONAL FERTILIZER PROGRAMS

The National Fertilizer Development Center (NFDC), a part of the Tennessee Valley Authority (TVA), is located at Muscle Shoals, Alabama. It has been developed into a fertilizer research, development, and education center during the past four decades. The Center was established to serve the fertilizer needs of the United States. In cooperation with State universities and the fertilizer industry—private and cooperatives—its programs have included a wide range of fertilizer activities throughout the United States. Most of the U.S. fertilizers are based on processes developed by TVA.

As the NFDC grew in stature it became recognized not only domestically but also internationally. European nations, Japan, and other more developed countries began to utilize this facility and its competence to supplement their knowledge in fertilizers. As additional nations became involved in the manufacture and use of fertilizers to improve their agriculture, requests to TVA and visitors to the Muscle Shoals facility quickly reflected this interest. Figure 1 indicates the growth rate in foreign visitors in recent years.

In the early 1960s the NFDC, at the request of the Agency for International Development (AID) and other international organizations, began to actively participate in fertilizer-related problems in the less developed countries (LDCs). By extending knowledge and experience gained in domestic programs to the international level, the NFDC has become the main source of fertilizer knowledge and expertise available to the U.S. foreign aid programs. Responding to the provisions of section 632(b) of the Foreign Assistance Act of 1961, as amended, the TVA and AID in November 1965 signed a general agreement in which AID recognized the unique personnel resources, capabilities, and experience of the NFDC relevant to fertilizers and sought "... to enlist as fully and effectively as possible, on a partnership basis, the pertinent resources of TVA in planning, executing, and evaluating those portions of the foreign assistance program in which it had special competence." This work has progressed and expanded to the extent that TVA has organized an International Fertilizer Development Staff to coordinate all international work conducted by the NFDC.

This paper summarizes the work and results of this cooperative effort between TVA and AID and other international organizations. This work

has fallen roughly into the following categories, and is described on the pages indicated:

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Library Services

Direct financial assistance was provided by AID during fiscal years 1967 through 1970 to help support the collection and cataloging of worldwide information on fertilizers. TVA is continuing this work as budget and personnel permit. Several thousand pieces of technical information on a wide range of fertilizer-related subjects are supplied annually in response to requests from developing countries. Literature reviews and bibliographies are prepared on selected topics from time to time. Many of the domestic requests also are for information to be used by U.S. industry, government officials, university personnel, and others working with or in the LDCs.

To facilitate the dissemination of information received and available in this facility, TVA in January 1968 began publishing *Fertilizer Abstracts*, a monthly compilation of current world information on the technology, marketing, and use of fertilizers. *Fertilizer Abstracts* is available on a subscription basis. Approximately 1,180 copies of each issue are distributed monthly, with more than 550 copies going to some 50 countries. The LDCs receive approximately 70 copies of the book by direct subscription; about 320 copies are channeled through AID/Washington for distribution through country missions.

Bibliographies on the mineral nutrition of major basic food crops—maize, rice, and wheat—based on available publications issued during the past 5 years—are being prepared for distribution to the developing countries. Copies of the full texts of many of the abstracted publications are stored on microfilm and can be reviewed at the NFDC library.

Statistical Services

Records on more than 2,000 fertilizer production facilities around the world—operating, under construction, planned, or shut down—are kept on computers at the NFDC. This provides an up-to-date and easily available inventory of fertilizer production capability by product for countries, regions, or the world. This information is in heavy demand by planners, financiers, importers, exporters, and others concerned with fertilizer projections.

Also on computers is information on fertilizer consumption by country—1956 to the present. This includes imports, exports, and consumption on a per capita and per hectare basis. This information is in wide demand and, along with this computer facility, is a basic source of information for such widely used publications as:

1. *Estimated World Fertilizer Production Capacity As Related To Future Needs*—a biennial publication by TVA.
2. *Fertilizers, An Annual Review of World Production, Consumption, Trade and Prices*—an annual publication by FAO.
3. Regional reviews of supply and demand as they relate to specific countries or trade areas.

The availability of this information provides a sound base for individual country and regional studies, including those listed later in this publication.

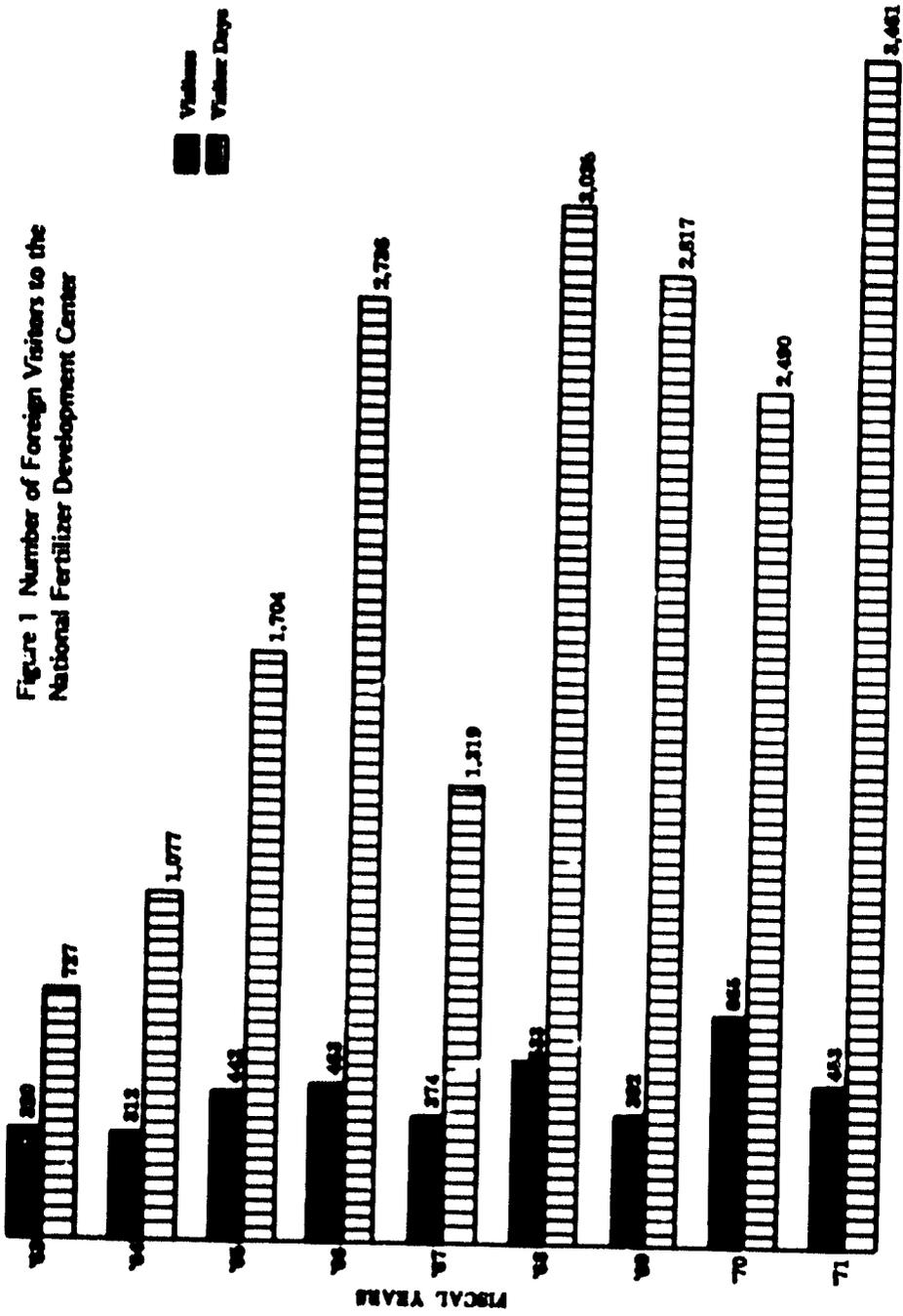
Training

Formal courses and on-the-job training have been available at the NFDC for LDC participants since 1965. Formal courses offered have included:

1. Fertilizer Production, Marketing, and Use
2. Fertilizer Use
3. Fertilizer Marketing
4. Fertilizer Plant Operators
5. Fertilizer Plant Maintenance
6. Corrosion and Instrumentation
7. Fertilizer Quality
8. Bulk Blending
9. High-level Management Seminars

Approximately 275 participants from some 25 developing countries have received formal training (50 in FY 1971). Even larger numbers have received informal training and work experience (see figure 1). Foreign visitors from the LDC's make up approximately 40% of the total foreign

Figure 1 Number of Foreign Visitors to the National Fertilizer Development Center



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visitors. They account for about 65% of the total visitor days since they usually stay much longer than do those from the developed countries.

Two training manuals - *Fertilizer Production, Marketing, and Use - A Handbook for Short Courses*, and *Training Manual for Fertilizer Plant Operators* - have been produced to supplement training at the NFDC. Under preparation are training manuals on fertilizer advertising and fertilizer plant maintenance. These manuals are designed to encourage training in the LDCs. Experienced cadres of training specialists are also available from TVA to help plan and organize training courses on a regional or individual country basis. The objective is not to conduct such courses but to encourage former participants and others in the LDCs to conduct training courses. The TVA cadres are to supplement where necessary to assure that useful and high level courses are available to a maximum number of participants in the LDCs.

Three such courses in fertilizer marketing are scheduled for FY 1972 in Indonesia, Brazil, and Afghanistan.

International Hospitality Committee

Through the excellent and enthusiastic cooperation of the Muscle Shoals community, international visitors and training participants have an opportunity to visit in private homes and participate in the social life of the community, both urban and rural. Although this is completely separate and apart from TVA, visitors and participants often comment on these opportunities to develop personal friendships as being unique and of great value in better understanding the American culture and way of life.

Special Studies and Surveys

The NFDC staff numbers some 250 scientists and engineers covering a broad range of disciplines and specialties. Through the general agreement with AID this competence is made available through the Technical Assistance Bureau to carry out agreed-upon studies, surveys, consultations, etc., of importance to the developing world. This same type of service is also available to and periodically utilized by other international organizations such as UNIDO, FAO, World Bank, foundations, and foreign governments.

Mineralogical Characterization of Basic Raw Materials

TVA researchers have examined and evaluated phosphate rocks from various sources, including several developing countries (Turkey, Iran, Peru,

India, Brazil, Colombia, Morocco, Tunisia, Liberia, Paraguay, and Saudi Arabia). These evaluations so far have been made primarily for research purposes on ways to characterize phosphate rocks for fertilizer use.

More than 500 phosphate rocks have been characterized in the TVA laboratories on chemical and mineralogical bases. Although AID funds have been utilized in only a few of these characterizations, they have permitted characterization of a number of rocks that otherwise would not have been included. Through these tests and experience, it is now relatively easy and inexpensive to rapidly identify usable rocks and to suggest the type of beneficiation and manufacturing processes best suited for making phosphate fertilizers. Indications as to agronomic response are also possible.

Some of the more promising rocks such as those from India, Iran, and Colombia have been tested further at the NFDC to determine how they can best be beneficiated and processed.

Research on Tailoring of Fertilizers for the Tropics

The NFDC is constantly working on new products and processes for the U.S. fertilizer industry. Through broad staff experience and contacts in the LDCs, specific fertilizer needs are identified and are now also recognized in this search.

Major effort at the present time is for improved fertilizers for paddy rice. Applied fertilizer, especially nitrogen, is much less effective under extreme conditions of leaching and volatilization. Efforts to control the release of applied nitrogen and possibly potash to more nearly fit the needs of the rice plant are showing promise, especially where water control is poor and not continuous.

Also, under paddy conditions, the available phosphorus balance is quite different than for upland soils. Possibly less soluble and cheaper sources of phosphatic fertilizers would provide the phosphorus needs of rice. Preliminary work indicates that this is true under certain soil conditions. Once these conditions are delineated and the degree of solubility that is acceptable is established, recommendations on products and processes to make these fertilizers will be possible. An international committee of recognized scientists from Japan, The Philippines, Thailand, India, Colombia, Peru, and the United States is providing guidance in the selection of fertilizers and in field testing of these materials on rice in some eight to ten countries over a wide range of soil and management conditions.

Provision of Special Expertise to Bureaus and Countries

Although it is generally felt that TVA's primary role in international work is one of providing short-term expertise for well-defined technical problems, longer term specialized assignments have been filled.

Between 1966 and 1970, one chemical engineer was assigned as a regional consultant on fertilizers to Latin America. He was assigned to the Organization of American States and worked with government officials, industries, and international organizations in the broad field of fertilizer production and use. He also functioned as secretary of the fertilizer work group of the Inter-American Committee of the Alliance for Progress. He wrote a series of reports on the organization and status of the fertilizer industries in Latin America.

An agricultural economist worked with the Technical Assistance Bureau during 1969 and 1970 in the capacity of providing technical assistance to AID's fertilizer procurement programs. This provided a direct tie with the NFDC in problems of fertilizer quality, analysis, bagging, and transportation.

A research chemist with experience in foliar analysis in rubber in West Africa is now working with the Rubber Research Institute in Nigeria. He is providing expertise in the establishment of a soil and plant analysis laboratory and in training technicians to operate this laboratory.

Work With Other International Organizations

USAID also encourages TVA to work with other international organizations. To date, this has included work with the FAO, UNIDO, the World Bank, the Atomic Energy Commission, the National Academy of Science, the U.S. Geological Survey, and with governments including Venezuela, Ecuador, Chile, and Peru.

International Fertilizer Development Staff

A small International Fertilizer Development Staff (figure 2) has been organized by TVA. It is responsible to the Manager of the NFDC. Its function is to marshal the center's best technical expertise and capabilities for conduct of agreed-upon international projects and activities. It coordinates the projects and activities within TVA and serves as a point of contact between TVA and the sponsoring international agency or organization.

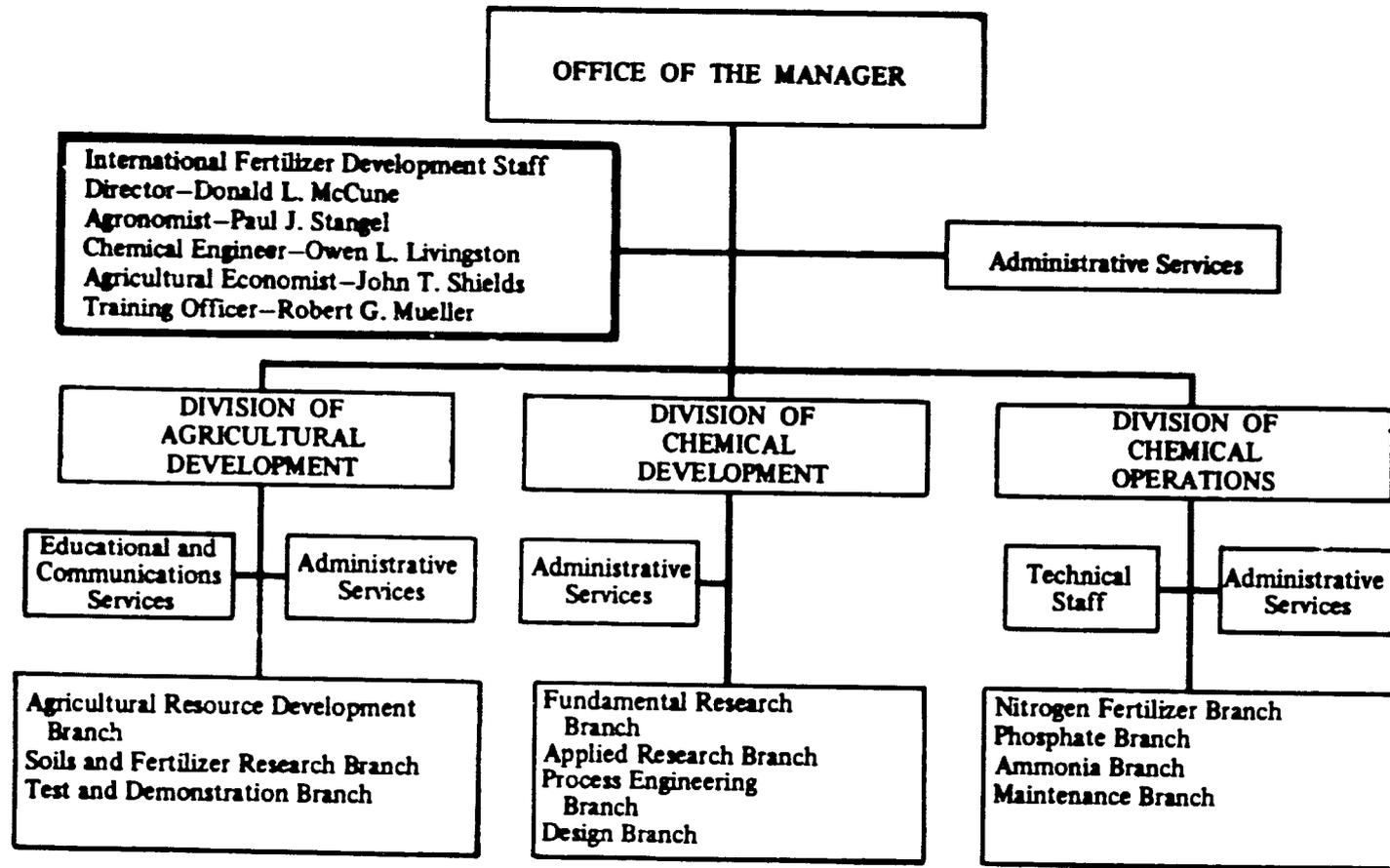


Figure 2. International Staff as Part of Fertilizer Center Organization

Technical Teams

Some 50 technical teams have worked in 25 developing countries since 1963 (figure 3). More than 60 staff members have participated. On occasion, outside specialists were obtained to supplement TVA expertise. TVA's multidisciplinary staff is well suited to a broad range of assignments and can rapidly respond to requests under the terms of the General Agreement with AID.

Study teams have addressed themselves to a broad range of problems. Some were oriented to engineering, others to marketing or agronomy. At times, overall studies are required and as many as five specialists make up a team. Such a large team might include engineering, geology, marketing, agronomy, and communications competence. These studies and surveys have served as the basis of much in-country planning by AID and other international organizations in their fertilizer action programs. The opportunity for TVA staff members to work firsthand with the problems and the people of the developing countries has also contributed to TVA's competence in providing information and training applicable to the needs of the LDCs. A synopsis of the work of these teams follows:

COUNTRY STUDIES

South Korea

In 1963, a three-man team—a chemical engineer, a design engineer, and an agricultural economist spent 8 weeks in South Korea making estimates of fertilizer consumption and advising on the type, size, and location of fertilizer production facilities required to meet expected needs. The report by this team pointed out that (1) Korean fertilizer use had reached a stage where large-scale manufacturing facilities could be justified on an economic and a foreign exchange basis, and (2) that urea and diammonium phosphate (DAP) better fit the Korean needs, from agronomic and economic standpoints, than the low-analysis single superphosphate which was being considered for production in numerous small-scale plants throughout the country. In addition to having a much higher plant food content, DAP could be blended with urea and potash to make needed complete fertilizers.

Impact—Following closely the recommendations, a fertilizer plant capable of producing 500,000 metric tons (mt) of plant nutrient was built



Figure 3. Technical Teams to Foreign Countries

and successfully operated in Korea. Since that time other plants have been built and Korea is now exporting nitrogen fertilizers. Fertilizer and lime use also increased rapidly and a second TVA team was requested in 1965.

The second team made fertilizer estimates for the period 1967-71 and advised on additional research and demonstration efforts to increase fertilizer use in line with Korea's growing food needs. These are reported in a publication titled *Projected Fertilizer Needs on Korea 1967-71*.

Impact Projected estimated consumption for 1971 was 800,000 mt as compared with 261,000 mt used in 1964. Consumption by 1970 had reached nearly 540,000 mt. The report has been widely accepted and used not only in Korea but also by other countries as an approach to follow in estimating fertilizer needs and as a guide for agronomic-economic research. This report is also considered and used as a text on fertilizers in Korea. It is also credited with spurring a rapid increase in the use of limestone, which increased from less than 100,000 tons in 1962 to almost 750,000 tons in 1966.

Morocco

Early in 1963, a chemical engineer and an economist went to Morocco to advise the government on the development of plans for a fertilizer complex at Safi. Recommendations were made on the technical aspects of this complex from size of plant to such items as sales organization plans, in-service training, the economics of production, and estimated market prices for the various products.

Impact The plant constructed closely followed the team's recommendations. Production of excellent quality concentrated superphosphate began in 1965; diammonium phosphate production based on imported ammonia started in 1967.

In 1966, an agronomist and an extension specialist spent 15 days in Morocco helping to plan a crash program to improve wheat production and to agree upon the scope of work and makeup of a team to make an in-depth study. Recognizing that the Moroccan government was serious in attempting to increase its wheat production, an action plan was made with the goal of fertilizing up to 200,000 hectares (ha) as compared to only about 50,000 ha that had previously been fertilized. Admittedly, this was an ambitious goal.

Impact Even though there was initial doubt as to the Moroccans' ability to carry out such an ambitious program, they actually did fertilize according to recommendations on more than 90% of the 200,000 ha.

The followup team (an agronomist, an economist, a chemical engineer, and an extension specialist) spent eight weeks in Morocco in late

1966 formulating a long-range fertilizer plan to help alleviate the country's wheat deficit. This team produced a report titled *Morocco Role of Fertilizer in Agricultural Development*. It spells out the fertilizer needs along with recommendations to improve production. It also recommends programs of research and extension, fertilizer distribution and marketing systems and the level of fertilizer production, including specific products, to meet Morocco's demands.

Impact Wheat production has markedly increased in Morocco. In 1968 Morocco's wheat production was its largest in history and 50% larger than when the program began. Nearly 350,000 ha of wheat were fertilized in 1968.

The report has been translated into French and serves as a textbook in Morocco. The Peace Corps also used it as a training and reference manual before it entered the wheat program in Morocco.

Since 1966, some 25 trainees have participated in IVA fertilizer courses, two engineers spent 10 weeks each working with IVA engineers at Muscle Shoals to get specific training in operation of fertilizer plants.

Iraq

In October 1963, IVA was requested by the Department of State (not AID) to send two chemical engineers to Iraq to evaluate plans and proposals submitted by the Soviet Union for a nitrogen fertilizer complex. This was to be Iraq's first venture into the fertilizer industry. The team also was to estimate the potential for domestic use of nitrogen fertilizers and evaluate the prospects for export from the proposed complex.

The team found that the proposed facilities were obsolete and made a counter-proposal using the newest technology for a similar nitrogen complex. They also urged that phosphate rock deposits be investigated more thoroughly and that fertilizer use in the country be stepped up markedly.

Impact Planning reports that have been received indicate that Iraq changed the design of its fertilizer complex to a more modern facility which included urea as one of its main products. A Japanese firm was understood to be the major contractor.

Thailand

In 1965, a three-man team (agronomist, economist, and engineer) was requested for Thailand to make a fertilizer survey. This team made a thorough review of existing information and estimated fertilizer use through 1970. The fallacy of using local lignite as a raw material for

ammonia production was noted and recommendations were made to use imported naphtha or imported ammonia. The report also spelled out the fertilizer distribution and marketing system that would be needed to reach the 1970 goals for fertilizer use.

Impact—The Thailand report has been widely used. Several hundred copies have been distributed, including copies to all missions as an indication of what is needed in the way of overall planning for an emerging fertilizer industry. Several American companies have contacted members of the TVA team for additional information to be used in developing a detailed proposal for fertilizer production and marketing facilities. Indications are that one or more companies became involved in the production and distribution of fertilizers in Thailand.

Nigeria

In 1965, a two-man team—chemical engineer, and marketing specialist—was sent to Nigeria to study the fertilizer situation and to recommend steps needed to get fertilizer use more in line with the needs of the country. The team was to recommend the type and kind of fertilizer industry that would best suit the needs of Nigeria. Upon arrival, it was evident that the AID mission in Nigeria, the contractual teams already there, and the Nigerian Government had not been adequately prepared for this study. As a result, a detailed study was not possible. Considerable time was lost in getting the survey under way and in making arrangements for proper contacts. For these reasons not enough information could be gathered to make the desired detailed recommendations.

Impact—Although a report was made to AID, it was not considered useful for the reasons given above and therefore was not distributed. We consider this trip a failure. However, it did emphasize both to AID and TVA the need for preliminary planning and the necessity for full agreement and understanding of the goals with the country before sending a team. As a result, no full-fledged TVA team now goes to a developing country without an advance team preceding them.

In FY 1970, TVA agreed to make a soil scientist, experienced in foliar analysis techniques in rubber, available for up to 18 months to oversee the establishment of an analysis laboratory and to train personnel to operate such a facility. To date, most of the equipment has been purchased and installed. The training of personnel to make it a success, however, has not proceeded to the extent expected due to internal problems of selection and assignment of personnel to this project.

Turkey

Late in 1965, TVA was requested to make a fertilizer survey for Turkey. To assure complete understanding it was agreed to send an advance two-man team to determine the scope of work and makeup of the team in cooperation with the Turkish Government. Agreement was reached and a five-man team—economist (member of the advance team), agronomist, chemical engineer experienced in phosphate production, chemical engineer experienced in nitrogen production, and mining engineer—was sent to Turkey in February of 1966. Members of the team spent up to 3 months in Turkey.

Major accomplishments of the team included: (1) A complete evaluation of phosphate rock deposits and their feasibility for use in making phosphate fertilizers. This study indicated that phosphate rock from Turkey would cost an equivalent of \$65/ton; rock could be imported for about \$15/ton. (2) A review of fertilizer use by crops, plus an estimate of fertilizer needs based on minimum food requirements for the next five years. This included the types and amounts of fertilizers required for specific crops. (3) A complete economic analysis of the feasibility of fertilizer production. This study indicated that fertilizer consumption had reached a stage that would support large-scale production. Further analysis showed where production facilities should be located and the type of materials that should be made.

Impact The general recommendations of this team have been followed in building a fertilizer industry for Turkey. (a) Plans for mining phosphate rock in Turkey have been discontinued—at a saving of from \$40 to \$50/ton of rock, phosphate rock will not be mined unless explorations result in a better grade material in the future. (b) Facilities are either being constructed or planned at each of four plant sites recommended. Product mix of the facilities has been changed to some extent from those recommended, but total capacities are being installed as recommended. (c) An experienced full-time specialist was hired by AID, as recommended, through TVA's help. This specialist has been instrumental in increasing total fertilizer use in Turkey and in helping to arrange for U.S. exports of fertilizers to that country. (d) Through TVA's recommendations, fertilizer imports are being used to "seed" the markets for the future plants. (e) TVA has been requested by the Turkish Government to help evaluate numerous proposals for building production facilities in Turkey. (f) Fertilizer consumption estimates proved to be too low. By 1969, Turkey was already using the amounts estimated to be used in mid-1970s.

During 1967, the economist and the chemical engineer of the first team were recalled to Turkey twice for consultation. Their primary effort

on these trips was to evaluate proposals by various U.S. companies for producing fertilizers in Turkey as compared to importing needed fertilizers. Recent reductions in world fertilizer costs made the reconsideration particularly advisable. This team established that ammonia would have to be imported at \$35/ton or less to convert to ammonium nitrate to compete with locally produced ammonia which could be converted to urea. Also, locally produced phosphoric acid should cost no more than \$135/ton of P_2O_5 to compete with imported finished phosphate fertilizers.

The end-of-tour report by an AID fertilizer advisor in Turkey dated July 1971 states, "The State Planning Organization adopted almost *in toto* the recommendations of the TVA study, and implemented them in the second 5-year plan. In the last 4½ years Turkey has invested a total of \$120 million in fertilizer plants."

Afghanistan

An advance team agronomist and economist spent 17 days in Afghanistan during September 1966. Its study indicated that an all-out effort would be required to increase fertilizer use to produce the food grains needed. As a result of the report of this team, TVA was requested to send another team.

In late March of 1967, TVA sent a three-man team agronomist, economist, and chemical engineer to Afghanistan to give overall guidance to the development of a fertilizer industry in line with present and projected fertilizer needs in Afghanistan through 1975. This will present a substantial challenge since Afghanistan's agriculture remains in a rather primitive state.

The followup team spent about 2 months in Afghanistan. The report was completed and Washington transmitted it to Afghanistan. This report reviews fertilizer use in Afghanistan and suggests research, demonstration, and action programs to increase the use of fertilizers to alleviate the growing food deficit. Fertilizer projections based on increased emphasis programs are made to 1977. Other than the Russian-financed ammonia-urea complex in northern Afghanistan, no additional production facilities can be justified before 1972, when the estimated fertilizer use will be 13,000 tons N and 10,000 tons P_2O_5 . Due to Afghanistan's inaccessibility and high cost of importing, fertilizer production facilities cannot be considered on the same basis as for countries having free access to ocean shipment. Therefore, it appears that it may be necessary for Afghanistan to first build single superphosphate facilities. If an adequate petrochemical source of hydrogen is not discovered, electrolytic production of ammonia

using hydropower that presently is unused may be the best consideration for nitrogen fertilizers.

Impact—Fertilizer use has increased rapidly. It is reported that by 1970 nitrogen use had reached 15,000 tons of nutrient. Phosphate use has increased much more slowly with virtually no dependable market being established.

Afghanistan recognizes that its major problem is, and for some time will continue to be, one of fertilizer distribution and marketing. To help overcome this problem, a few participants have been sent to the U.S. for training. TVA also has been requested to help in conducting a marketing course in Afghanistan early in calendar year 1972.

Pakistan

An advance team consisting of a chemical engineer and an agronomist spent 3 weeks in Pakistan during March-April 1967. The major objective of the team was to outline the scope of work for a larger study on fertilizer production, distribution, and use in Pakistan.

The team recommended that a followup four-man TVA team spend a maximum of 2 months in West Pakistan to develop a detailed analysis of fertilizer needs and production and marketing possibilities. Because the agricultural situation in East Pakistan is so different, the team recommended that two members of the main team spend several days in East Pakistan to outline the scope for a possible future team to this part of the country.

Impact Although there have been numerous discussions about a followup team none has been requested. TVA has been contacted about a fertilizer dealer training program in Pakistan and has furnished a number of informational items containing guidelines for setting up a good dealer training program.

Venezuela

During the month of December 1966, a three-man TVA team—agronomist, chemical engineer, and mining engineer—visited Venezuela at the request of the Instituto Venezolano de Petroquímica (IVP). The team reviewed and made suggestions on three basic problems concerning fertilizers: (1) phosphate rock mining operations at Riecito, (2) chemical engineering aspects of a proposed IVP fertilizer plant expansion at Morón, and (3) agronomic aspects of IVP's fertilizer program.

Impact Followup of this study and numerous contacts with IVP personnel indicate that significant changes are being made in plant design

as well as in sales and services programs in line with recommendations in the report.

India

Since 1965, continuous contact has been maintained with India. Eight different groups have been called to India to work on a broad range of problems. Annual participation in the Fertiliser Association of India seminars has become expected. Major accomplishments include a plan for reorganization of the public sector fertilizer organizations to meet the needs of the coming decade and to work harmoniously with the private sector and cooperatives

Impact—It is understood that these recommendations were implemented along the lines suggested.

A team of engineers spent about 3 months working with the Trombay unit in helping overcome operational and maintenance problems. A stepwise plan for altering existing plant and operational procedures was drawn up and presented to the Trombay staff.

Indications are that these alterations are being followed and a much improved production record is being attained.

In 1970, three TVA engineers, specialists in maintenance, corrosion, and instrumentation, were contracted to work with FCI and FACT production units. As a result, a plant-by-plant evaluation and plan of work was established in an attempt to improve production. It was pointed out, however, that in many cases other factors, especially power supply problems, are overriding limitations which must be overcome before production can reach acceptable levels. Also in 1970, a TVA engineer was requested to participate in a seminar on corrosion for FACT. As a result of these teams a continuing stream of correspondence is received requesting advice on in-plant problems.

India continues to send the major part of participant trainees to TVA courses. During 1971 a total of 26 Indians participated in marketing courses. Other participants included engineers, quality control officials, and high-level management.

South Vietnam

A three-man team—chemical engineer, agronomist, and economist—spent about 1 month in early 1967 in South Vietnam evaluating that country's fertilizer industry. A coal mining and utilization specialist was attached to the team to evaluate coal reserves.

One of the major objectives of the team was to evaluate the technical and economical feasibility of the proposed fertilizer complex at An Hoa. Generally, the analysis showed that in view of the tremendous investment already made, proceeding with the fertilizer complex would be better than any proposed alternative use of facilities. From a technical standpoint, some facilities might be considered obsolete, yet overall they should be capable of satisfactory operation. Another factor, and one which the team could not determine, was whether the area could be secured and made safe for use as an industrial complex. The study also made recommendations for planning toward a nitrogen fertilizer complex in the Mekong Delta and outlined plant nutrient needs of the country over the next several years.

Economic analysis showed that considerable savings in fertilizer costs could be achieved by importing finished high-analysis phosphate fertilizer rather than ground phosphate rock, as has been done to a considerable extent in the past. The team also emphasized that South Vietnam's long-range plans for a fertilizer industry should provide for participation of private fertilizer companies.

Impact The An Hoa plant has not been continued as the area could not be secured. Recommendations on changes in distribution procedures and practices were agreed to in early 1968 and subchanges were made. The economist member of this team has been recalled several times to review plans and progress. He spent 3 weeks in South Vietnam in July 1968 as part of this review and wrote a followup to the original report spelling out the progress to date and recommending future steps in the effort.

In April 1971 another team was requested. This team was asked to review three proposals for the construction of fertilizer plants in Vietnam; and to further advise on the type of facilities best suited under present conditions in Vietnam and the world fertilizer situation in general.

Uruguay

During February-March 1967, a chemical engineer spent 7 weeks studying the Uruguayan fertilizer market, industry, and potential for manufacturing development. This study was in collaboration with the Inter-American Committee on the Alliance for Progress (CIAP).

The report indicates that additional phosphate production facilities appear warranted in the next few years to meet the growing demand for fertilizers. Expanded needs for nitrogen and potash, however, probably can be better satisfied through imports. With a dominant agricultural economy in Uruguay, and at least 80% of the foreign trade income derived from export of livestock products, greater use of fertilizers should encourage agricultural diversification and improve the export picture.

Peru

A three-man advance team—agronomist, chemical engineer, and economist—spent 2 weeks in Peru during June-July 1967, evaluating a proposal for establishing a nitrogen plant in northern Peru. They also discussed with the Government of Peru and industry officials the possible need for additional studies of Peru's potential for fertilizer manufacturing and for developing an effective fertilizer marketing system.

The team found the urea-ammonia complex to be adequately designed (conventional), to be well located from the standpoint of both internal and external markets to fit Peru's needs from the agronomic standpoint, and to be justified since Peru already needs about half of its production in its internal markets. Questions were raised, however, on the internal pricing and on the lack of plans for "seeding" the market so that Peru could receive full benefit from this production facility.

The advance team also pointed out the need for additional efforts in the fields of education, demonstrations, and improved marketing. As a result, TVA was asked to work with the Peruvian counterparts to draw up plans to implement programs that will increase fertilizer use and decrease the necessity for importing food crops.

Impact—Due to TVA's comments on pricing and "seeding" efforts, a second marketing proposal presenting more realistic internal pricing policies and indicating a major effort in "seeding" programs was drawn up. To assure TVA concurrence in this new proposal, the TVA team leader was recalled at the company's expense to review plans with consortium representatives.

During November and December 1967, an agronomist and communications specialist spent 3 weeks in Peru. They visited and interviewed fertilizer distributors, sales offices, government education and development agencies, farmers' associations, and farmers along the Coast and in the Sierra. The preliminary data were summarized at TVA and plans made for completing the study. In January, the agronomist and communications specialist returned to Peru, accompanied by an economist and a chemical engineer. This team spent 6 weeks studying the potential fertilizer market and other factors relating to fertilizer distribution and marketing.

The team found an unattended need for phosphate and potash fertilizers, a low level of fertilizer knowledge among dealers, practically no fertilizer merchandising program, and a tax structure and distribution system hindering expansion of fertilizer use. Recommendations were made to start training programs, establish bulk blending plants, begin marketing anhydrous ammonia in certain areas, revise and remove certain taxes, limit the geographical area where guano is sold, and alter the method of

subsidizing high-cost domestic fertilizer production. The team also made a special report to AID/Peru concerning a fertilizer loan designed to increase the effectiveness of fertilizer education and promotion programs and rapidly increase fertilizer use.

Impact—The report has been published and distributed. Even with the changes in government, AID indicated that the report was being used and the changes in line with the recommendations had been made.

Tunisia

During June and July 1968, a two-man team made a study of the Tunisian nitrogen fertilizer situation. A report titled *Nitrogenous Fertilizer Requirements and Potentials for Local Production* is available for distribution. This report estimates the nitrogen fertilizer needs for the Tunisian wheat program and compares methods for meeting these needs through import or by local production. The final decision on how to meet these needs will depend on the value placed on foreign exchange.

Saudi Arabia

During July-August 1968, a two-man team, sponsored by the U.S. Geological Survey, made a feasibility study on mining, processing, transportation, and marketing of Saudi Arabian rock phosphate. They evaluated mining, beneficiation, and processing of the rock to finished fertilizers. The prospects for marketing on the world market in light of only limited domestic demand should be the determining factor if this project goes forward. This report made to the Saudi Arabian Government and the U.S. Geological Survey is being utilized internally and to date no outside distribution is possible.

Indonesia

In May and June 1968, a joint USAID/TVA team was sent on an emergency basis to evaluate the current needs for fertilizers and the ability to receive, store, and distribute fertilizers in Indonesia. This team emphasized the need for further help in marketing.

In September 1969, an agronomist and an economist returned to Indonesia to consult with the Indonesian Government and AID on distribution and marketing problems. The report from this study entitled *Fertilizer Distribution in Indonesia 1969* points out the need for more coordination in importation and sales efforts, the need for better inventory and sales records, and the need for a much more aggressive sales effort as short-run solutions.

It further recommends that the marketing division should consider a complete reorganization of its staffing and sales effort to make it more efficient and better able to handle the anticipated large increases in sales to a more diversified group of farmers.

In February 1970, the team was recalled to Indonesia to further expedite the recommended reorganization. Two reports, *A Followup Study on Indonesian Fertilizer Distribution Problems* and *A Reorganization and Marketing Program for P. N. Pertani* were published. They noted the changes being made and outlined additional changes that would be beneficial to the fertilizer industry of Indonesia. Special emphasis was given to the dire need for training in marketing and for a full-time management and marketing specialist to help implement the suggested changes.

In September 1971, TVA was contracted to conduct the first in a series of fertilizer marketing training courses starting with high-level management. TVA was also requested to supply the management and marketing specialist. This specialist is a part of the training team and expects to start a two-year assignment in Indonesia in early 1972.

Iran

In late 1968, a chemical engineer spent 4 weeks in Iran evaluating the technical and economic prospects for utilization of Iranian phosphate ore for fertilizer production. A report, entitled *Prospects for Utilization of Iranian (Shemshak) Phosphate Ore for the Production of Fertilizers*, was issued. This evaluation points out the problems of using the common sulfuric acid acidulation on this rock, but suggests that the production of normal superphosphate or nitric phosphates is a possibility. Advantages of such a complex would include: closer proximity to present market, the use of Iranian raw materials, low foreign exchange outlay and provision of work for 600-800 people in an area presently depressed due to decline in coal mining. The disadvantages would be: low analysis material; low water solubility of phosphates, which might not be desirable for the high pH soils of Iran; and competition from the huge nitrogen plants in southern Iran that use very cheap raw materials. This project was funded by the United Nations Industrial Development Organization.

Impact - As a result of this study the United Nations contracted with TVA to conduct "bench tests on phosphate rock to determine its suitability for manufacture of nitro-phosphate fertilizer: conditions of calcination, degree of grinding, conditions for acidulation with nitric and sulfuric acid, rates and efficiency of filtration and washing, exploratory ammoniation and granulation tests." These tests have been completed and

a publication, "Report of Bench-Scale Studies of Nitric-Sulfuric Acidulation Process for Use of Iranian (Shemshak) Phosphate Ore", has been submitted to the U.N.

Chile

In May 1969, a two-man team spent 2 weeks in Chile considering a proposal for a study team from TVA to advise on the best method of supplying Chile's fertilizer needs over the next decade. Both local production and importation are to be considered. It was agreed that TVA could make such a study but only after demand figures were furnished by the Banco del Estado from a study being conducted under contract with A. T. Kearney Company.

In January 1970, drafts of the Kearney study were furnished to TVA and the Corporacion de Fomento of Chile requested that TVA make this supply study and relate it to the needs and the production potential of the other Andean countries. This study was made in late 1970 and a report, *Fertilizer Supply Study for Chile*, has been presented to CORFO.

Bolivia

In June 1969, a two-man team spent a week in Bolivia advising on a fertilizer loan and agreeing upon a scope of work, timing, and staffing needs for an in-depth study of the Bolivian fertilizer situation as further backup of an anticipated AID fertilizer loan.

The second team--an agronomist, an economist, communications specialist, and a chemical engineer--spent about 2 months, September and October, in Bolivia collecting data and information for this study. Due to political problems in Bolivia it was necessary that the team leave Bolivia prior to completing the study. Through correspondence, adequate information has been received and the report, *A Fertilizer Program for Bolivia*, was issued in June 1970.

Ecuador

In June 1969, two engineers were made available to work in Ecuador with a fertilizer production facility based on TVA design that was having trouble in reaching design capacity and producing high quality fertilizers. These engineers worked directly in the plant and were able to suggest design changes to work out the problems and train operators so that the plant could operate as designed.

Colombia

In June 1969, an economist and an engineer spent 4 weeks in Colombia helping to establish fertilizer use goals and identifying problems in fertilizer production facilities and blending plants that were preventing manufacture of high-quality fertilizers at reasonable cost. In February 1970, two engineers returned to Colombia to further consult and advise on design changes, maintenance, and operation of these plants to make them more efficient. Their report, *Engineering Evaluation of Selected Fertilizer Production Facilities in Colombia*, provides both short and long-term suggestions for improving the production from these plants. As a result, Fertilizantes Colombianos S.A. (FERTICOL) has contacted TVA for further assistance in carrying out this work. The first effort will be for FERTICOL to send two or three engineers to TVA to work on redesign and to contact equipment and construction firms to effect these changes.

Brazil

In late 1969, a three-man team spent 4 weeks in Brazil considering the possibility of making an overall marketing and distribution study. While in Brazil it was discovered that ANDA (the National Association of Fertilizer Manufacturers) had proposed a similar study to be financed by Brazilian funds. The team recommended that every opportunity should be given for this study to be made by this Brazilian effort. TVA agreed to advise and consult to help make this study more effective. ANDA has been working closely with the International Fertilizer Development Staff of TVA in planning this study. In November 1970 a two-man team--an engineer and an economist--was sent to Brazil to review this study, which has been delayed as a result of contracting difficulties. Through ANDA, Brazil has requested that a 1-week course in fertilizer marketing be conducted for high-level management personnel during November 1971.

Paraguay

In January 1970, a two-man team spent 10 days in Paraguay helping to justify and write a loan paper for \$1.5 million to cover fertilizer imports for 1971 and to agree upon a scope of work, timing, and staffing of an overall study of the fertilizer situation in Paraguay. It was agreed that TVA would consider making such a study during September-November 1970 and that it would require three men for a period up to 3 months to complete this study. The suggestion was made that the North Carolina Soil Fertility Project be brought into this study and possibly furnish the agronomic expertise as needed.

This study was made in September-October 1970 by a team composed of three TVA staff members, an agronomist from North Carolina State University, and a geologist from the U.S. Geological Survey. The team also looked into both phosphate rock and limestone deposits in Paraguay. The result of this work is reported in a publication entitled *Lime, Fertilizer, and Agricultural Potential in Paraguay*.

Philippines

During March and April 1971, a TVA economist and an agronomist spent 7 weeks in the Philippines in a joint effort with a Technical Working Committee of the Presidential Fertilizer Commission. The objective of this study was to provide the Philippine Government with alternatives for further development of its fertilizer industry and to advise on ways to improve distribution and use. A report, *The Fertilizer Industry in the Philippines*, was issued in July 1971 on parts of this work.

Kenya

A TVA agronomist-chemical engineer team spent 4 weeks in Kenya during November 1970 making a preliminary survey of the fertilizer situation and relating it to other East African Community countries. A report entitled *Preliminary Survey of the Kenya Fertilizer Industry* includes estimates of fertilizer use in Kenya and neighboring countries and presents some alternatives for Kenya in establishing its fertilizer industry. The report further spells out the objectives and scope of work should this study be continued. Kenya has expressed interest in additional work.

INTERNATIONAL RELATED STUDIES

Country Studies

- * 1. Korea--Mixed Fertilizer Plant for Korea: Project Evaluation. 1963.
- 2. Projected Fertilizer Needs for Korea, 1967-71. 1965.
- 3. Morocco--Role of Fertilizer in Agricultural Development. 1967.
- 4. Report on the Development of the Turkish Fertilizer Industry. 1966.
- * 5. A Report on the Thailand Fertilizer Situation and Potential. 1966.
- * 6. Survey of Fertilizer Use in Nigeria--An Evaluation of Potential Demand and Methods of Supply. 1965.

*Not available.

- * 7. The Role of Fertilizer in the Agricultural Development of Afghanistan. 1968.
- 8. Tunisia–Nitrogen Fertilizer Needs, Alternatives to Meet Needs. 1968.
- * 9. The Report of the Fertiliser Study Team - India. 1968.
- *10. The Trombay Unit of the Fertiliser Corporation of India, Ltd. 1967.
- *11. Uruguay's Fertilizer Supply and Need. 1967.
- *12. South Vietnam–An Evaluation of the Fertilizer Industry. 1967.
- 13. Peru's Fertilizer Distribution and Marketing System. 1968.
- *14. Phosphate Deposits in the Sirhan-Turaif Area of Saudi-Arabia Mining-Processing, Transportation-Marketing, Feasibility Study. 1968.
- *15. Prospects for Utilization of Iranian (Shemshak) Phosphate Ore for Fertilizer Production. 1969.
- 16. Fertilizer Distribution in Indonesia–1969.
- *17. Report of TVA Technical Team's Visit to Instituto Venezolano de Petroquímica, November 29-December 11, 1966.
- 18. A Fertilizer Program for Bolivia. 1970.
- *19. 1970 Follow-up on Indonesia Fertilizer Supply/Demand Situation.
- 20. Engineering Evaluation of Selected Fertilizer Production Facilities in Colombia. 1970.
- 21. A Reorganization and Marketing Program for P. N. Pertani (Indonesia). 1970.
- *22. Fertilizer Supply Study for Chile, 1971.
- 23. Lime, Fertilizer, and Agricultural Potential in Paraguay. 1971.
- 24. The Fertilizer Industry in the Philippines. 1971.
- 25. South Vietnam's Fertilizer Situation and Alternatives for Production. 1971.

Others

- 1. Estimated World Fertilizer Production Capacity as Related to Future Needs. 1966. 1968. 1970.
- *2. Seminar for Latin American Fertilizer Executives Proceedings. 1967.
- 3. Importance of Water Solubility of Phosphorus Fertilizers. 1966.
- 4. Economic Evaluation of Producing Mixed Fertilizers in India by Ammoniation of Triple Superphosphate vs Ammoniating Phosphoric Acid to Diammonium Phosphate. 1966.
- 5. Ocean Shipment of Anhydrous Ammonia vs Urea-Ammonia Solution. 1966.
- 6. Economic and Technical Evaluation of Overseas Shipment and Utilization of Elemental Phosphorus for Fertilizer Production. 1968.

7. Economic Evaluation of Overseas Shipment and Utilization of Phosphoric Acid for Fertilizer Production. 1968.
8. Characteristics of the World Fertilizer Industry Phosphatic Fertilizers. 1968.
9. Economic Comparison of Overseas Manufacture and Importation of Anhydrous Ammonia. 1969.
10. Technical and Economic Evaluation of Fertilizer Intermediates for Use by Developing Countries. 1970.
- *11. TVA's International Fertilizer Effort. 1969.
12. TVA's International Fertilizer Programs. 1970. 1971.
13. Producing Granular Fertilizers. 1970.
14. Design of Equipment to Produce Phosphoric Acid from Elemental Phosphorus. 1970.
15. High-Yielding Cereals and Fertilizer Demand. 1970.
16. Directory of U.S. Port Facilities for Exporting Fertilizer. 1970.
17. Prospectus for Training Courses.
18. Training Manual Fertilizer Production, Marketing, and Use. 1970.
19. Training Manual for Fertilizer Plant Operators. 1970.
- *20. Comparison of Urea Processes. 1970.
- *21. Recent Advances in Fertilizer Technology. 1970.
22. Future Prospects of Elemental Phosphorus and Furnace Acid. 1970.
23. Urea Technology: A Critical Review. 1970.
24. Technology and Economics of Complex Fertilizer Production. 1970.
25. A Case Study of the Feasibility of Shipping Bulk Urea Fertilizer Under Tropical Conditions. 1971.
26. Nutrition of Maize. 1971.
27. The Feasibility of Shipping Bulk Fertilizer Materials into Developing Countries. 1971.
28. Economics of Sulfuric Acid Production. 1971
29. Improvement in Efficiency of Handling Bagged Fertilizer. 1971.
30. Nutrition of Rice. 1971.
31. Changes in the World Fertilizer Market and Effect on the CFETO Countries.

SUMMARY OF TVA/AID COOPERATIVE WORK

Year	Training Courses			Technical Assistance ^b			Budget for War on Hunger	Other	Total Budget	
	No.	Part.	Countries ^a	Budget	No.	Countries				Budget
1964	—	—	—	—	3	3	\$ 26,161	—	—	\$ 26,161
1965	1	20	1	\$ 7,483	2	2	38,370	—	—	45,853
1966	1	41	6	32,339	5	5	72,198	\$ 17,030	—	121,567
1967	1	2	1	1,000	11	9	171,200	63,000	—	235,000
1968	4	72	28	58,850	14	7	193,200	145,000	—	397,050
1969	4	49	8	49,519	8	6	89,438	458,750	—	597,707
1970	5	41	6	15,500	12	11	267,000	611,500	—	894,000
1971	4	50	9	56,825	7	7	220,564	620,000	22,800	920,269

^aIndia, Turkey, Venezuela, Kenya, Brazil, United Arab Republic, Mexico, Chile, Ecuador, Costa Rica, Uruguay, Bolivia, Peru, Israel, Morocco, El Salvador, Colombia, Tunisia, Pakistan, Indonesia, Ghana, British Honduras, Afghanistan.

^bIraq, Korea, Nigeria, Thailand, Morocco, Venezuela, Uruguay, South Vietnam, Pakistan, Afghanistan, Turkey, India, Peru, Indonesia, Tunisia, Saudi Arabia, Bolivia, Chile, Colombia, Ecuador, Brazil, Paraguay, Indonesia, The Philippines, Kenya.

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