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# TRANSFER OF KNOWLEDGE IN FERTILIZER RESEARCH AND DEVELOPMENT WITH SPECIAL EMPHASIS ON EXTENDING THE TVA FERTILIZER PROGRAM TO DEVELOPING COUNTRIES

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TRANSFER OF KNOWLEDGE IN FERTILIZER RESEARCH AND DEVELOPMENT WITH SPECIAL EMPHASIS ON EXTENDING THE TVA FERTILIZER PROGRAM TO DEVELOPING COUNTRIES

Although the Tennessee Valley Authority was established as a regional development agency, it was given national responsibilities in one area--the development of better fertilizers and fertilization practices for introduction to American farmers. TVA was charged with these responsibilities because a significant national need existed and because of the potential for using idle facilities at Muscle Shoals, Alabama, to help meet that need.

First, the fertilizer industry was not upgrading its materials. It was content to sell low-quality products in the traditional manner. Farmers had little reason to demand better fertilizers since most had no idea that improvements were possible or practical. They had few resources for experimenting with new farming practices; life was a hand-to-mouth situation, with most farm families considering themselves lucky to provide most of the necessities of life.

No one--in government, the universities, or the fertilizer industry--was aggressively concerned with improving fertilizers, which were low in plant food content, powdery with a tendency to solidify into hard cakes, and fairly costly. The universities had established the need for fertilizers, especially in the older farming region of the South. State governments provided quality control through inspection services to verify that fertilizers were as good as stated on their labels. But no one was encouraging manufacturers to make fertilizers that contained more plant food, handled better, or sold for less per unit of nutrient. And no institution or agency had either the physical facilities for broad chemical and engineering research to develop new fertilizer technology or a mission heavily oriented in this direction.

On the other hand, there existed in the vicinity of Muscle Shoals, Alabama, two Federally-owned chemical plants built during World War I for defense purposes. One was an unsuccessful experiment to make ammonium nitrate by the synthetic process. The other was built to produce ammonium nitrate by the cyanamid process. This plant had gone through a test run after the armistice, but was obsolete by the time of TVA's creation. Moreover, the Defense Act of 1916 had specified that these Muscle Shoals facilities could be used to make fertilizer during peacetime.

Thus, the country had a major need for a system to upgrade fertilizer production technology and use. The Tennessee Valley region had some chemical plants and appurtenant facilities that might serve as a nucleus for such an effort. Congress responded by giving the facilities and the responsibility for fertilizer improvement to TVA.

## The Beginning

TVA's first step in meeting its fertilizer responsibilities was to determine the most pressing nutrient needs of the region. Less than three months after taking over the nitrate plants, TVA officials met with directors of the region's state agricultural experiment station. They jointly agreed that first priority should be given to work with phosphate. Although both nitrogen and phosphate were needed on southern soils, they reasoned that nitrogen fertilizer alone would be insufficient to ensure healthy crops. Applications of phosphate would be of greater help in revitalizing nutrient-depleted soils by making it feasible to grow leguminous crops which would extract nitrogen from the air.

Almost immediately, TVA chemical engineers, working first at the University of Tennessee and then at Muscle Shoals, developed a practical

method for producing concentrated superphosphate, a fertilizer containing nearly three times as much plant food as the phosphate available commercially. Two electric carbide furnaces from the old nitrate plant were put into operation by early 1935 to smelt phosphate rock found in the region (south central Tennessee). The phosphorus was then converted to phosphoric acid which was used to make the improved phosphate fertilizer.

In the meantime, TVA had signed a Memorandum of Understanding with area state land-grant universities and the U.S. Department of Agriculture for a coordinated program of agricultural research, extension, and land-use planning in the Tennessee Valley. TVA's primary role would be to supply phosphate fertilizers for demonstration farmers' use. The universities, through their established staffs of local county agents, would implement the programs. Research efforts of all three institutions would be coordinated.

This set the stage for a massive demonstration program in the Tennessee Valley. TVA supplied thousands of tons of concentrated phosphate free to county associations who distributed it to demonstration farmers. Cooperating farmers, paying only freight and handling charges, agreed to use the fertilizer on pastures and cover crops--not on traditional row crops--and to show their neighbors the results. State Extension agents helped demonstration farmers develop sounder farming systems and arranged thousands of tours to show other farmers the advantages of scientific agriculture.

Thus, the TVA fertilizer program whose responsibility was national in scope, began as an integral part of TVA's regional resource development effort. By choosing the electric-furnace route to high-analysis fertilizers,

TVA took advantage of low-cost electricity available at Wilson Dam and of nearby low-grade phosphate deposits not suited for fertilizer production by the usual commercial processes. Expanded use of improved phosphate fertilizer added to farmers' incomes. Emphasis on growing soil-protecting crops, along with terracing and other conservation practices, began to solve a severe soil erosion problem. This improved agricultural production and protected the TVA system of lakes from siltation.

The fertilizer program was expanded in the late 1930's. Engineers experimented with methods to produce other types of high-analysis phosphate fertilizers and contracts were executed with out-of-Valley experiment stations for research with TVA fertilizers in other parts of the country. By 1938, for example, 31 non-Valley states and the U.S. Department of Agriculture were testing experimental TVA fertilizers. Twelve of these states also were participating in the test-demonstration farm program, an effort which both introduced an improved fertilizer and promoted better farming methods. In addition, TVA phosphate was being made available to the Agricultural Adjustment Administration, which distributed it to farmers as grants to aid the national program of soil conservation.

## The Age of Growing Up

Early fertilizer programs were bearing fruit and new economic forces were appearing on the horizon as TVA entered the 1940's. The most dramatic impact came from the wartime emergency. TVA had been mandated a national defense responsibility and this effort consumed up to half of the fertilizer research and production effort for several years. Perhaps the single development of this period that most influenced the future of the TVA fertilizer program was the building of an ammonia plant. Its first

objective was to provide material for producing ammonium nitrate for use as an explosive during the war. But better explosives were developed and the ammonium nitrate capability was diverted to fertilizer use. TVA helped develop a process for making ammonium nitrate safe to handle and use, and TVA was the leader in introducing it as a new fertilizer to farmers across the country.

TVA now had capability to produce both phosphate and nitrogen fertilizers. The products it was introducing were much higher in plant food content than those generally available. Going to the next stage--products containing both nutrients--was a relatively simple matter. High-analysis mixtures containing all three primary plant nutrients would follow.

The intense wartime research effort in laboratories and pilot plants, some of which was directly related to fertilizers, resulted in a base which greatly strengthened the Agency's abilities. The staff had been augmented. Facilities had been added. Experience and expertise had been gained in many areas. All of this argued well for the national fertilizer program.

Basic changes also were recorded in the fertilizer introduction and education phases of the program. As farmers moved to use more fertilizer and began to get acquainted with the improved products less incentive was necessary to achieve testing and adoption. This led to the institution of a partial-pay system. The amount of the payment was increased gradually until demonstartion farmers now pay about two-thirds of the market price for fertilizer supplied by TVA.

To achieve even wider introduction, TVA also began to sell limited amounts of its high-analysis fertilizers to farmer cooperatives.

Diversity in Maturity

Research that at first was aimed primarily at supporting TVA's production efforts was, by the 1950's, generating a momentum of its own.

Numerous technological innovations had been recorded, most of them concerned with improved production methods for phosphorus and its products, and dozens had been patented. With nitrogen capability, the opportunities for further gains expanded manyfold.

A process perfected early in the decade set the stage for a revolution in the fertilizer industry. Gaseous ammonia is the cheapest source of nitrogen. Adding it to phosphate, to make a two-nutrient product, previously had to be done in a batch operation. Granulation, if done at all, was a completely separate step. TVA developed a single process for continuous ammoniation and granulation. Pilot plant results were so promising that a special demonstration was held to show it to the industry. Some 300 observers attended and the process was quickly adopted throughout the industry. This process paved the way for high-analysis mixed fertilizers and established the basis for other processes.

TVA began in 1955 to produce and introduce diammonium phosphate, a product which had been around a long time but which had been too expensive for general fertilizer use. This drawback was overcome by development of an economical process, based on commercial wet-process phosphoric acid, that yielded a granular 18-46-0 or 16-48-0 fertilizer. The process was adopted rapidly by the industry and DAP soon became a leading world fertilizer.

From 1956 onward, TVA has played a significant role in upgrading fluid fertilizers. The key was development of superphosphoric acid, containing 76 percent or more $P_2O_5$. Its high analysis is advantageous, but its unique ability to improve physical properties of final fertilizer products is equally significant. Researchers have made many improvements in both the solution and suspension types of fluid fertilizers. Their most recent

major development is the simple and economical pipe-reactor process for making fluids. More than 50 companies began using the process in less than 3 years after the introduction of a small-scale model.

Other products which TVA has either developed or advanced include nitric phosphates (26-13-0 and 20-20-0), ammonium phosphate nitrate (30-10-0 and 25-25-0), solid ammonium polyphosphate (15-62-0), and ammonium nitrate sulfate (30-0-0-5S). Work has begun in the late 1960's on new uses for urea, which was becoming a leading nitrogen fertilizer in many parts of the world. TVA now is introducing a granular urea, which has distinct advantages over the commercial prilled product, and a new family of urea ammonium phosphates (28-28-0 and other grades). Sulfur-coated urea, which releases its nitrogen slowly to crops, is in advanced stages of development and has attracted considerable attention.

Another change in the fifties was the expansion of distribution channels to include proprietary industry firms. The objective in selling experimental TVA fertilizers to private firms is basically to speed the acceptance process. As a private company uses a few tons of a new fertilizer, it gets first-hand knowledge of it and can better evaluate its potential in its own manufacturing and marketing systems. Also, the product can be introduced to more farmers, thereby beginning market development while the final stages of research are still underway.

In the industry sales program, TVA charges as close to the market price for nutrients as possible--the going market price, or a few dollars per ton difference--to get firms to try the new products. Manufacturers and distributors, in turn, contribute other costs associated with their own experimentation and market development.

## The System and How It Works

Elements of all levels of research and of extension programs to promote the use of developments have been present almost from the beginning. But they became much more clearly delineated, and the roles of each more clearly identifiable, as the program evolved. The TVA National Fertilizer Development Center today is an institution with a full range of capabilities for developing new fertilizers and introducing them to farmers and the industry. Each element of course, has its own role. But no group operates in a vacuum. Each is consciously a part of the total, contributing to the overall objective of making better and more economical fertilizers available to American farmers. The TVA fertilizer research and development program is unique. Schematically, the entire system can be visualized as shown in figure 1.

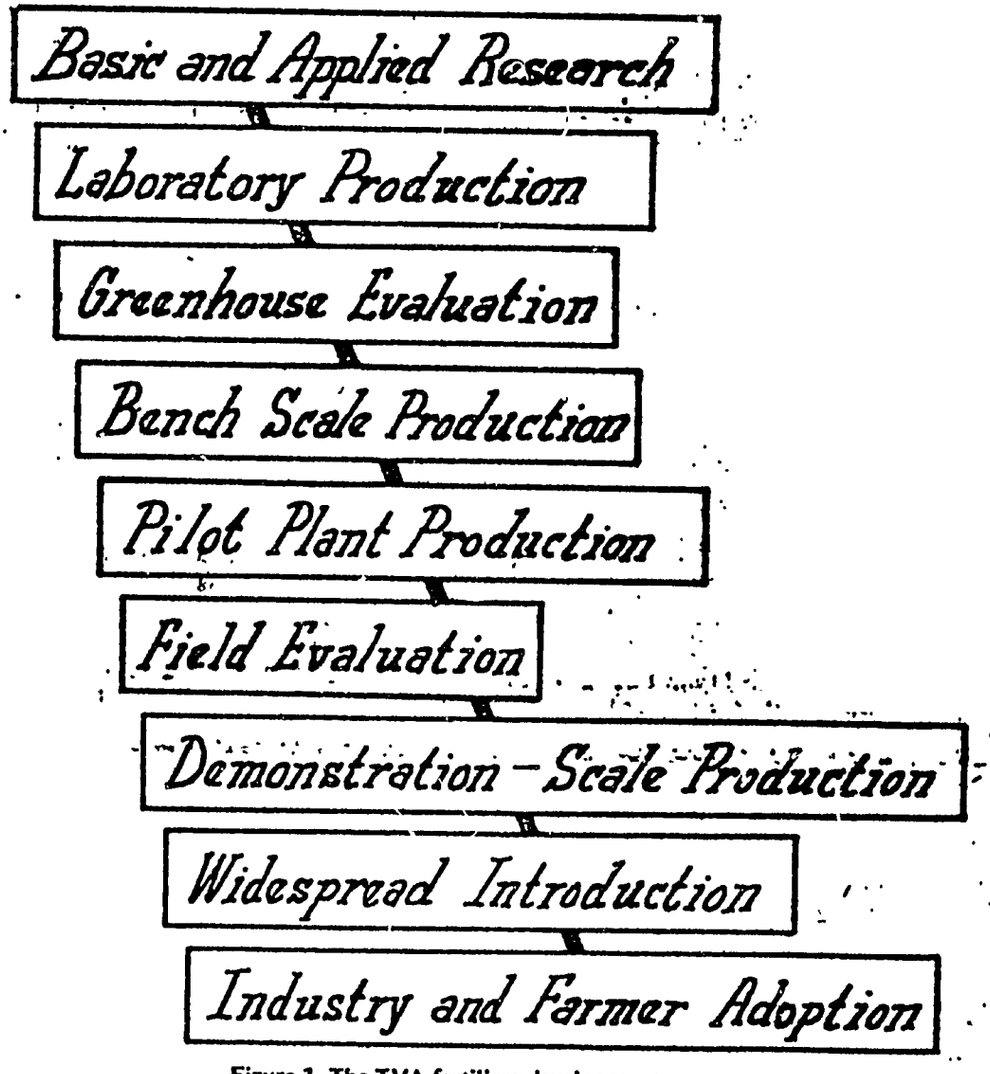



Figure 1. The TVA fertilizer development system

Fundamental researchers apply the techniques of physical chemistry to lay the groundwork for developing new fertilizers and for gaining better understanding of soil-fertilizer relationships. They identify various physical properties of fertilizer raw materials and compounds under different conditions. This suggests how more effective fertilizers can be developed or how processes of their manufacture can be improved. Small quantities--a few ounces or pounds--of prospective new fertilizers often are made in laboratory equipment.

On the other hand, the chemists also support other research groups by outlining parameters within which desirable chemical reactions can be obtained and undesirable reactions avoided in plant equipment. Their sophisticated microscopic and submicroscopic investigations often reveal why or in exactly what manner an experimental method fails to function properly.

Selection of projects for intensive study is guided by problems for which solutions are known to be needed and the current overall emphasis of program--i.e., improved efficiency of nitrogen use, more effective recovery of phosphate from low-grade ore, higher analysis fluids, etc.

Agronomists and soil scientists work closely with the chemists and others and evaluate the potential of new fertilizers on important crops. The first evaluations are made in pot tests in the greenhouse. Preliminary screenings can be made with a few ounces of product from the laboratory. Promising products are tested more fully later in plots at Muscle Shoals and by cooperating university experiment stations.

Studies of the mechanisms of nutrient uptake, crop nutrient requirements, and soil system interactions provide useful guidance for product developers.

Engineers develop and test and refine fertilizer manufacturing processes. This is done in a range of equipment sizes, from bench-scale equipment that produces several pounds per hour to pilot plants that make several hundred pounds per hour. Data obtained on materials of construction and operating variables are used to design larger TVA demonstration plants or by the industry. Miniature operating units give fertilizer manufacturers an early view of how the process might perform. They also provide the substantial quantities needed for widespread product testing, in research plots and in limited farm demonstrations.

The engineers stay abreast the methods and problems of the fertilizer industry. Some of their investigations are aimed primarily at resolving industry problems. Other work is done with a view as to how it might mesh with existing commercial production systems. Projects also may be oriented to manufacture experimental fertilizers that meet special analyses or quality specifications prescribed by agronomists.

Large demonstration production units are used to complete process development and to provide sufficient product for meaningful introduction to farmers and the industry. There is no such thing as "automatic scale-up" of fertilizer production processes. Adjustments and refinements are necessary in each successively larger operation. While some processes are adopted by the industry directly from the pilot plants, this often is not the case. A lot of engineering still is needed to perfect the process for large-scale development, to iron out the final flaws, and to get a better determination of the problems and advantages on a commercial scale. Experience has shown that pursuing new processes through small pilot plants to semicommercial-size units is essential to eliminate the major risks associated with new engineering developments in order to achieve a rapid, orderly transfer of technology to the producing industry.

Educational programs to channel new knowledge and new products to potential users are the final step. These take many forms, including a biennial "Open House" which TVA holds to show the industry its latest developments, a general "open door" policy for technical visitors at all times, and widespread publication of research findings.

Cross-country formal ties with the fertilizer industry and universities route new fertilizers to farmers all over the Nation. New products are evaluated in plots and in practical operations on several hundred farms each year in cooperation with universities in some 38 states. Demonstration farmers often double or triple their gross income during a 5-year participation period--ample evidence of the potential for fertilizers used intelligently along with other good practices and good farm business management.

About 90 percent of TVA's production of experimental fertilizers (250,000 tons annually) is used in educational activities with more than 200 fertilizer firms in some 43 states. The main objective is to get more people acquainted with the new fertilizers and to help build markets. Manufacturers need to try a new fertilizer in conjunction with others that they normally process. Distributors and dealers need limited tonnages to test the market and to begin to generate a demand if the new fertilizer warrants commercial production. And farmers need to try new fertilizers in practical operations; this is the final test of market worthiness. Engineers and other TVA field representatives work closely with industry firms to help fit new technology into their operations. National and regional conferences on technology and marketing also further program objectives.

TVA's basic policy is to produce moderate tonnages of each new product that appears to have commercial potential--until the main production problems are resolved, the potential is adequately demonstrated, and demand has grown to the point that commercial producers are taking over the market. Thus, TVA is continually phasing out its older products and phasing its newer ones into its demonstration production and introductory programs.

To insure that all of its developments are widely available, TVA obtains patents whenever possible and then grants nonexclusive licenses for any interested company to use them. More than 500 plants in 39 states have been licensed to use patented TVA developments. Several--such as the TVA ammoniator-granulator, the diammonium phosphate process, and various liquid fertilizer production methods--have become industry standards.

A basic point in the TVA philosophy is the emphasis on high-analysis fertilizers. This has been evident from the beginning--concentrated phosphate in lieu of normal superphosphate, ammonium nitrate to replace nitrate of soda, high-analysis mixtures, and the current emphasis on urea-based products. The reason is simple--to reduce nutrient costs to the farmer. Products that contain more rient per pound are an effective way to achieve this goal since a third or more of the farm price represents transportation and handling costs. This emphasis has paid off handsomely; today's fertilizers in the United States contain more than twice as much plant food as those of 30 or 40 years ago.

Another basic point is that TVA does not consider its job in fertilizer development done until the new product is in practical use. Recalling the diammonium phosphate example will make clear how this works. Although not a new product when TVA began producing small quantities in the mid-fifties, little had been used as a fertilizer. TVA thought it had

a good potential and began introducing it to demonstration farmers. Cooperating fertilizer distributors also began to introduce it to their customers. As farmers became acquainted with the new material, demand for it began to grow. About the same time, TVA engineers worked out a process by which diammonium phosphate could be produced more economically with wet-process phosphoric acid. From there, demand and production of this high-analysis fertilizer skyrocketed from a few thousand to more than two million tons a year. TVA didn't do the job alone, but was an important catalyst in the development.

Analysis of and response to market conditions also are integral parts of the TVA program philosophy. An example is the work to develop and introduce better quality fluid fertilizers, including suspension products which have capability for more nearly equalling dry mixtures in plant food content. Studies to define the potential of bulk blending and distribution systems and research to develop products especially suited to such systems are other examples. Others include the development of simple formulation charts which mixers could use to determine the least-cost combination of ingredients to make specific grades and the recent extension of this type activity to computer models which can be accessed by individual firms.

## Extension to Other Lands and Other Areas of Concern

TVA has no legal authority of its own for pursuing fertilizer problems and developments outside the United States. However, since the early 1960's, TVA has encouraged, facilitated, and participated in the transfer of fertilizer technology to developing countries. The basic philosophy of TVA's international fertilizer efforts are expressed in the 1965 general agreement between TVA and the Agency for International

Development (AID) ". . . 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 United States foreign assistance program in which it has special competence." This competence encompasses fertilizer production, marketing, and use technologies from the National Fertilizer Development Center.

Resources Available for International Work

TVA's National Fertilizer Development Center (NFDC) employs some 250 scientists covering a broad range of disciplines and specialities. In addition to the professional staff, the NFDC maintains extensive facilities consisting of chemical and engineering laboratories, pilot plants, demonstration scale production facilities, farm and industry demonstration and educational programs, training and communication services, an extensive library, etc. The international program uses these staff services and facilities as is necessary and convenient.

On occasion, TVA must enlist outside consultants to supplement its' expertise. This is generally the case when a very specialized ability is required or when existing staff cannot be made available during the period requested.

How the Program Works

Due to the nature and magnitude of the international fertilizer program, TVA created an International Fertilizer Development Staff (IFDS) to coordinate its international activities. Functions of this staff are to: (1) marshall TVA's technical expertise and capabilities for conduct of agreed upon international projects; (2) coordinate international activities with TVA and serve as liaison between TVA and the sponsoring organization

or agency; (3) evaluate requests for technical assistance and serve on reconnaissance missions in preparation for detailed in-country studies; (4) serve on technical teams; and (5) maintain a close working relationship with the world fertilizer community. Although most international efforts are sponsored by AID[1], TVA works with and through many international organizations, such as the United Nations (FAO and UNIDO); International Bank for Reconstruction and Development IBRD (World Bank); The Atomic Energy Commission, other United States Government agencies, The National Academy of Science, private corporations, foundations, international technology centers, and foreign governments, such as, Venezuela, Brazilia, Colombia, Ecuador, Peru, Chile, and Indonesia.

Program Elements

TVA's fertilizer international research and technical assistance program can be delineated into several activities. The major program categories include:

Research on Improving and Developing Fertilizers for the Tropics

The National Fertilizer Development Center is constantly searching for new fertilizer products and processes. Because of its international responsibilities, this effort has been expanded to include tropical soils and crops.

TVA scientists, recognizing that tropical soils/fertilizer/crop relationships differ from conditions in temperate zones have been, and are, involved in extensive research in Asia, Latin America, and Africa. TVA experimental fertilizers have been tested on paddy and upland rice in such

[1]The funding for TVA's technical assistance through the international program must be totally reimbursed by the users.

countries as the Philippines, Thailand, India, Indonesia, Peru, Colombia, Brazil, Ghana, Nigeria, etc. This research includes a number of important tropical crops--sugarcane, pineapple, tropical pastures, cassava, and perennial tree crops (cocoa, bananas, coffee, oil palm).

This research is also considering the effect of multiple and intercropping on fertilizer needs. Slow-release fertilizers, such as sulfur-coated urea, are showing effective results in multiple cropping schemes.

Phosphate rock, as a source of $P_2O_5$ through direct application, is being tested. Efforts to improve phosphate solubility through low cost techniques are also being evaluated. Micronutrients and secondary elements are being used to determine their role in crop production on tropical soils.

This research is being conducted in cooperation with the international research centers and research institutions in several developing countries. Through this research media and cooperative efforts, TVA has the opportunity to participate in institutional planning, especially at the research level.

Market Research

TVA economists are engaged in global, regional, and country fertilizer analyses on a continuing basis. Data on the status of more than 2,000 fertilizer plants throughout the world are computerized in the National Fertilizer Development Center's fertilizer data bank. This data provides current and easily available information on fertilizer production capacity by product for countries, regions, and the world. Such data is

in heavy demand by planners, financers, researchers, importers, exporters, and institutions concerned with fertilizer market studies.

As a result of formal cooperation with FAO, worldwide supply and demand data since 1956 is on TVA computers. Thus a time series data base is available for individual country and regional studies. Development and maintenance of the data has made it possible for FAO to accelerate publication of its annual report--"Fertilizer, an Annual Review of World Production, Consumption, Trade, and Prices."

Training

Training courses in production, marketing, and use have become an important part of TVA's effort to transfer the latest fertilizer technology to the developing world.

Formal courses and on-the-job training have been available at the NFDC for participants from developing countries since 1965. Formal courses offered have included: Production Marketing and Use; Methods of Marketing; Fertilizer Use Practices; Plant Operating Techniques; Plant Maintenance Techniques; Corrosion and Instrumentation; Quality Control; Bulk Blending; and Management Seminars.

Participants from about 28 developing countries have received formal training. Many others have received informal training and work experience.

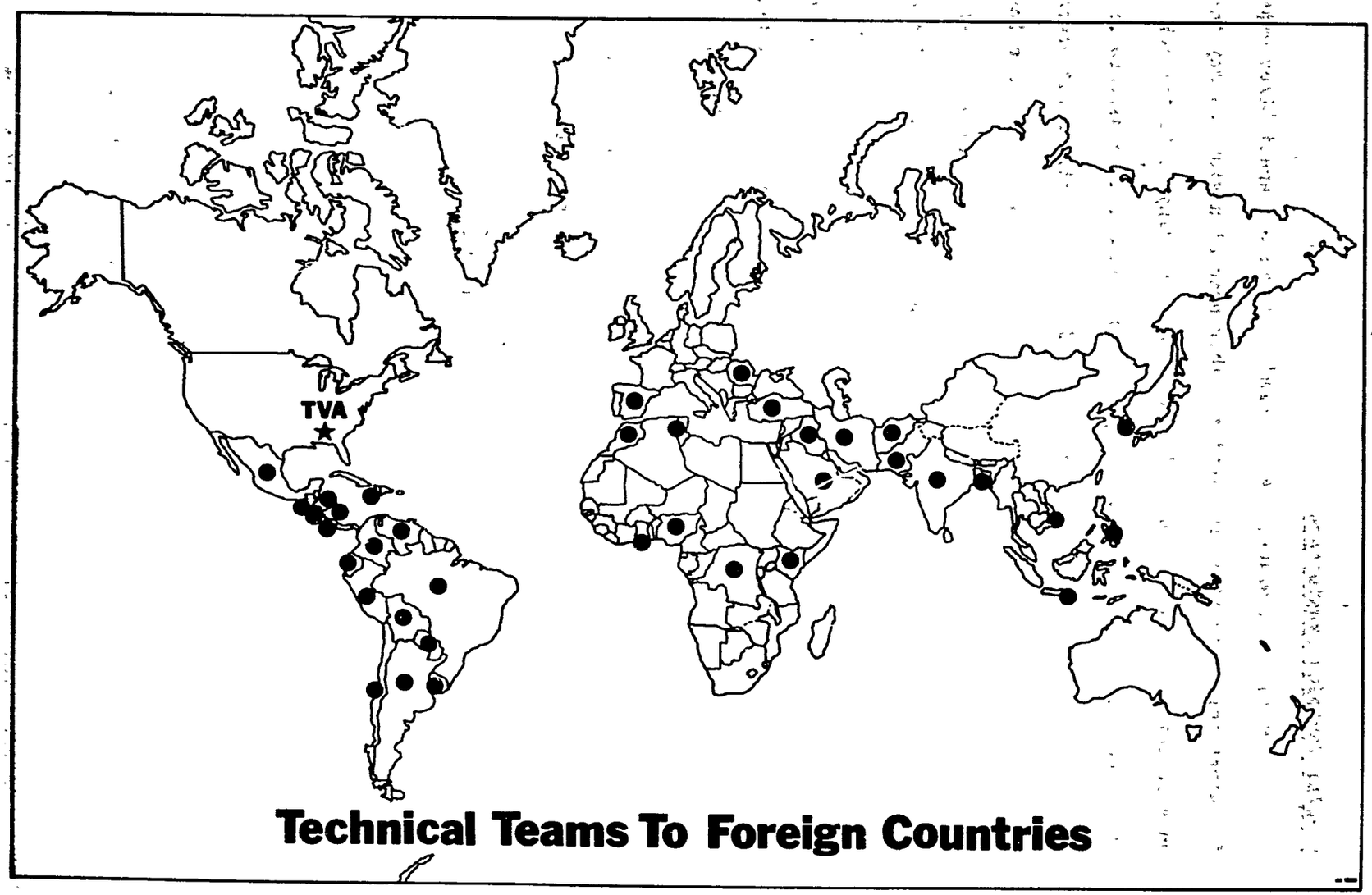
Training manuals in Fertilizer Production, Marketing, and Use--A Handbook for Short Courses; Fertilizer Plant Operators; Fertilizer Advertising; and Fertilizer Plant Maintenance, have been produced to supplement training at the NFDC. These manuals are designed to encourage training in developing countries. Experienced training specialists are

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 developing countries to conduct training courses. The TVA specialists supplement where necessary to assure that useful and high level courses are available to a maximum number of in-country particpants.

Country Studies

TVA responds to numerous requests for technical teams to be sent to developing countries. These teams are short term (about 90 days) and thus must be skilled in rapidly diagnosing fertilizer related problems, evaluating alternatives, and recommending practical solutions. Some 75 technical teams have conducted such studies in 37 developing countries since 1963 (figure 1). Nearly 100 staff members have participated.

Study teams have tackled a broad range of problems. Some were oriented to engineering, others to marketing or agronomy. At times, comprehensive 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 developing countries.




**Technical Teams To Foreign Countries**

Special Technical Assistance

On many occasions, TVA is asked to provide a specialized expertise for short term counseling and advice. This special assistance may involve an engineer in "trouble-shooting" and "debottlenecking" a fertilizer plant or an economist advising a government on fertilizer policy matters or an agronomist consulting with country officials on a fertilizer use problem. Such assignments are considered to be an important aspect of TVA's international program. Further, these assignments permit our technical staff to work at all levels with industry and government officials in developing countries.

Although TVA's primary role in international work has been one of providing short-term expertise for well-defined technical problems, long-term specialized assignments have been and are still being filled. Long-term assignments (1 to 2 years) have included:

- A chemical engineer assigned to the Organization of American States (OAS) as a regional fertilizer consultant to Latin America.
- An economist working with AID's Technical Assistance Bureau as a technical advisor to AID's fertilizer program.
- A research soil chemist working with the Rubber Research Institute in Nigeria providing assistance in the establishment of a soil and foilar analysis laboratory and necessary technician training.
- An agronomist serving as Agricultural Inputs Advisor to the USAID mission to Indonesia. This assignment included assistance to other Asian nations.
- A marketing specialist serving as fertilizer advisor to the USAID mission to Ghana (new assignment).

Mineralogical Characterization of Basic Raw Materials

TVA researchers have examined and evaluated phosphate rocks from various sources, including many developing countries (Turkey, Iran, Peru, India, Brazil, Colombia, Morocco, Tunisia, Liberia, Saudi Arabia, and Paraguay). These evaluations have been made primarily for research purposes on ways to characterize phosphate rocks for fertilizer use.

Several hundred phosphate rocks have been characterized in the TVA laboratories on chemical and mineralogical bases. Although AID funds have been used in only a few of these studies, they have permitted characterization of a number of rocks that otherwise would not have been included. Through these tests and experience, it is now easy and relatively 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, Pakistan, Peru, and Colombia--have been tested further at the NFOC to determine how they can best be beneficiated and processed, especially for direct application.

Library Services

The internatinal program has helped 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. Many domestic requests are for information to be used by the world fertilizer industry,

government officials, university personnel, and others working with or in the developing countries.

To facilitate the dissemination of information received and available in this library facility, TVA publishes 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. Several thousand copies are distributed, with copies going to about 50 foreign countries.

Bibliographies on mineral nutrition of major basic food crops--maize, rice, and wheat--have been prepared for distribution to the developing countries. Copies of the full tests of many of the abstracted publications are stored on microfilm and can be reviewed at the NFDC library.

International Visitors

Foreign visitors from developing countries account for about 50% of total foreign visitors to TVA. However, these same visitors account for about 70% of total foreign visitor days since they usually stay much longer than those from developed countries.

In 1974, 328 foreign visitors spent an average of nearly six days at the NFDC (figure 2). Since most visitors from foreign countries are interested in technical information, considerable staff time was spent in preparation for discussion of technical matters.

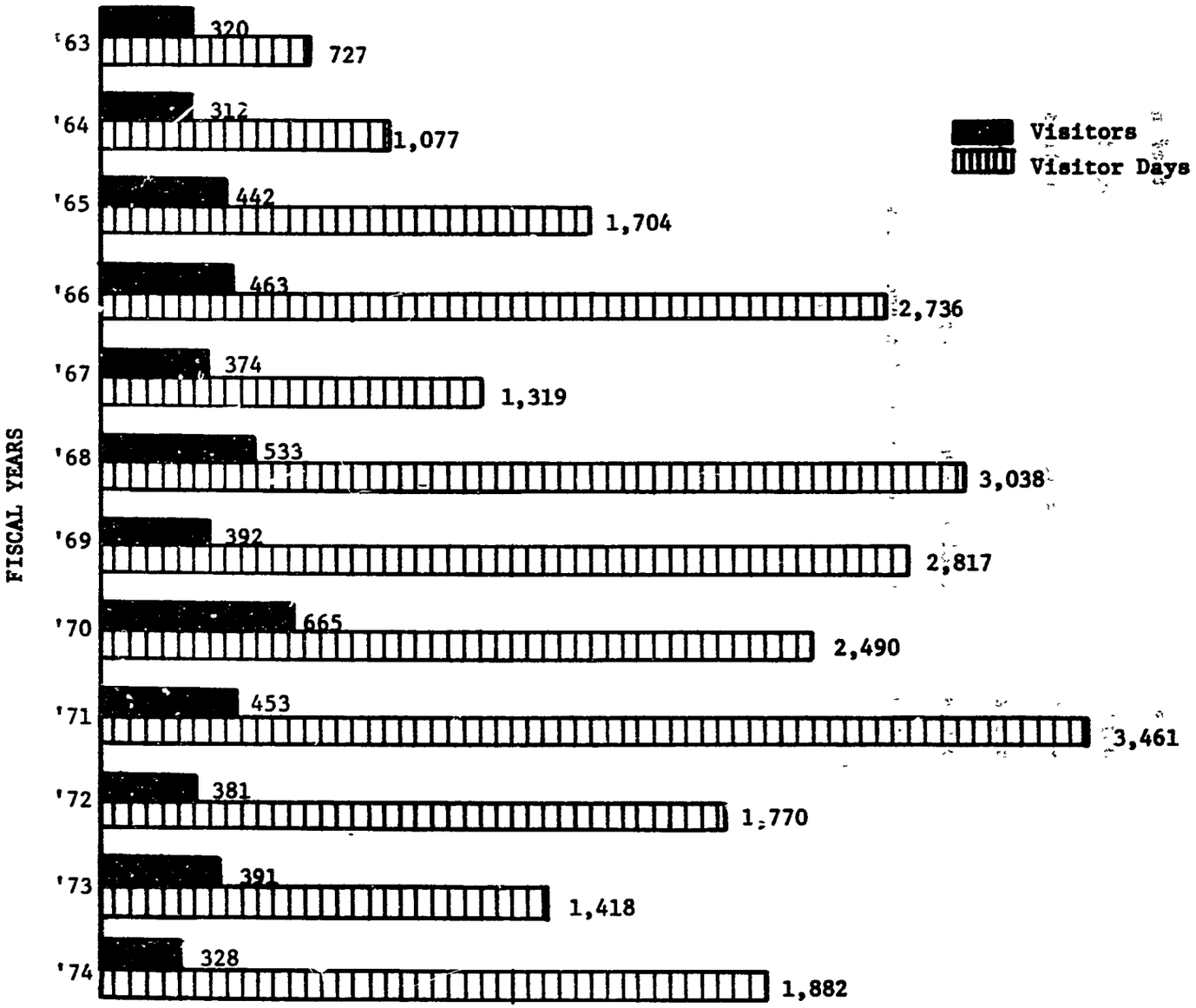



Figure 2 . Number of Foreign Visitors and Visitor Days to the National Fertilizer Development Center

Summary

TVA is constantly evaluating its international research and technical assistance efforts. The program is continually changing to keep pace with changes in the world food and fertilizer situation. To keep abreast of new developments and opportunities for improvement in fertilizer programs in developing countries, TVA staff particpates in a host of country, regional, and global conferences and seminars.

Through its work and cooperation with other international organizations, TVA is helping to improve food production and the well-being of the developing world's population.