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NEW TECHNOLOGY - ITS IMPACT ON FERTILIZER MARKETING

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Paper to be Presented at
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NEW TECHNOLOGY - ITS IMPACT ON FERTILIZER MARKETING

By Donald L. McCune*

The seminar held in May 1970, in which TVA also participated, gave primary attention to technological aspects. You looked critically and indepth at where you were and where you could go to make your industry more viable and more responsive to your rapidly expanding and changing market. You have made notable progress and the fact that you are now in this seminar giving major emphasis to marketing is an indication of your success on the supply side. You recognize that for your industry to keep moving ahead all phases must move at reasonable rates. Increasing supply without corresponding increase in the market can have catastrophic effects in any industry and fertilizers are no exception. Much of the world has not recognized this and chaos has taken its toll. You can be commended for recognizing at a relatively early stage in the development of your industry that marketing is an important and essential part of your activities.

You also are to be commended for recognizing that even though this is a marketing seminar you must take into account new developments or potential developments that could materially affect your marketing strategy. Fertilizer is intensively oriented toward technology and any significant change in technology can have a tremendous effect on marketing. Likewise, new technology can lie dormant and ineffective unless marketing systems are devised to take full advantage of the new technology. Prediction of how a new technological advance or change will manifest itself in the market is all important to the success--or even survival--of those whose corporate living depends on the marketing of fertilizers or fertilizer intermediates.

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*Director, International Fertilizer Development Staff, Tennessee Valley Authority, prepared for presentation at Marketing Seminar on Fertilizer Industry, sponsored by ANDA, Sao Paulo, Brazil, November 21-27, 1971.

Changes That Have Occurred.

A look at the changes that have occurred over the past few decades emphasizes that rapid change must be expected.

The dominant fertilizers today include ammonium nitrate, urea, triple superphosphate, ammonium phosphates, and high-grade potassium chloride. In some areas anhydrous ammonia, nitrogen solutions, ammonium polyphosphate solutions, suspensions, and phosphoric acid are becoming common place. Almost all of these materials have achieved their popularity since 1945. In 1945, ammonium sulfate and sodium nitrate were still the principal nitrogen materials; as late as 1950, ordinary superphosphate still supplied 80 percent of the P_2O_5 for manufactured fertilizers.

If we can project our experiences into the future, we must expect that new materials will become dominant and that some of those now widely used will decline. Also, those materials that remain popular may change in form; an example is the growing demand for granular, course and solution-grade potash.

The fertilizer materials that are now popular, however, did not become so as soon as they were recognized as potential fertilizer materials. For instance, diammonium phosphate was manufactured for fertilizer use in Germany about 1930. Even earlier (probably before 1850), Sir James Murray used ammonium phosphates in fertilizer mixtures. Nevertheless, diammonium phosphate did not become an important fertilizer until the 1960's. Similar histories could be related about urea, triple superphosphates, and many other materials. From this we might conclude that the new fertilizers of the future, at least those for the next decade are already here. We need only to look about us and see what materials are being used or are under experimental study and then try to decide which of these materials will be the winners in this decade.

So we come to the question of how to forecast the success of new materials. Again, we might seek answers in our experience. Why was diammonium phosphate a failure in 1930 and a success in the 1960's? Why did it take so long for urea to become a popular material?

We often say it is due to technological improvements. This is true to a degree. Improvements in phosphoric acid have strengthened the economic position of ammonium phosphates and triple superphosphates. Developments of an economical granulation process perhaps was even more important in setting the stage for diammonium phosphate's surge. Gradual improvements in production processes also improved the economic position of urea. Rising costs of transportation and labor have also helped the relative position of the higher analysis materials.

Another answer to the delayed popularity of some new materials is that it takes time for them to be fitted into the marketing and distribution system. Most new materials have succeeded only when means were discovered or devised to fit them into a marketing system that gave farmers what they needed--namely, a variety of fertilizers, flexibility of formulation, and convenience of application.

For example, diammonium phosphate did not fit very well into the marketing and distribution systems of the United States in the 1940's and 1950's. At that time most fertilizer phosphorus reached the farmers in the form of granular and non-granular mixed fertilizers. The use of diammonium phosphates in such mixtures seemed to promise only marginal advantages. A modest market was forecast.

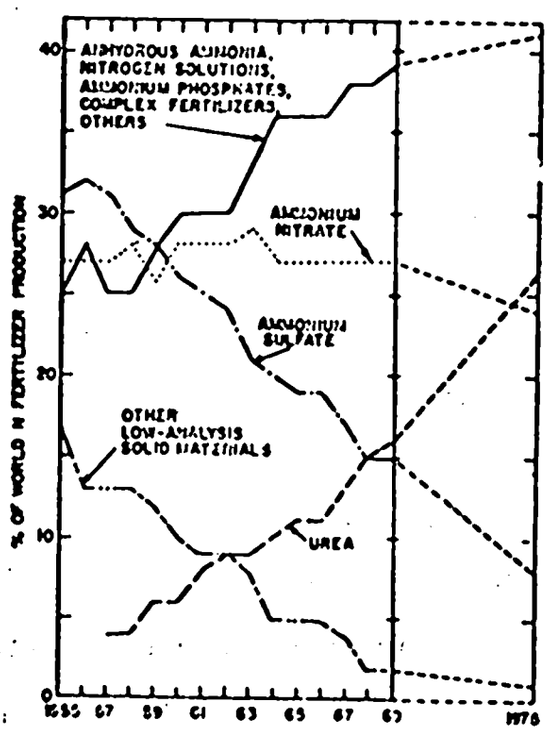
In the 1960's, bulk blending--the practice of combining granular fertilizers into physical mixtures--developed as an important marketing and distribution system. Diammonium phosphate fitted nicely into this system; it can be said that bulk blending in the United states made diammonium

phosphate successful - or was it that diammonium phosphate made bulk blending successful? Whatever the case, it was the wedding of new technology and a new marketing system.

So much for the past let us look to what may be ahead for the future.

Trends in Nitrogen Fertilizer

A prominent feature of the world nitrogen industry over the past 15 years has been the rapid rise in popularity of urea--a trend expected to continue in the future. Urea's share of the world market has risen from less than 5 percent in 1955 to 16 percent in 1969 and we are projecting an increase to 26 percent by 1975. Use figures are based on FAO data through 1969 for the world (less USSR and Communist Asia); the projections are based in part on estimated capacity for the coming years. These figures are for solid urea only and do not include the urea content of solutions. (In the United States, about half of the urea for fertilizers goes into solutions.) Also, the FAO data probably do not include the urea content of some complex fertilizers.



The largest group consists of anhydrous ammonia, nitrogen solutions, the nitrogen content of ammonium phosphates and complex fertilizers, and miscellaneous other materials. Ammonium sulfate, once the most popular nitrogen material, supplied only 15 percent of the world market in 1969, and may decline to 8 percent in 1975. (Undoubtedly, there is and will continue to be a fair tonnage of ammonium sulfate used in mixtures which is not reported separately.) Other low-analysis materials include calcium nitrate, sodium nitrate, and calcium cyanamide. This group now supplies only 2 percent of the market. Ammonium nitrate now supplies 27 percent of the market; in future years the percentage may decline slightly.

The following tabulation shows estimates of world capacity for production of urea, ammonium sulfate, and ammonium nitrate in 1967, 1971, and 1975.

	World nitrogen capacity,[a] 1000's of metric tons								
	Ammonium sulfate[b]			Ammonium nitrate[c]			Urea		
	1967	1971	1975	1967	1971	1975	1967	1971	1975
Western Europe	1320	1570	1750	2591	3833	3,979	1426	3,071	3,320
Eastern Europe	276	300	370	1008	2402	2,500	620	1,541	2,376
Asia	916	1161	1217	300	500	500	1846	4,714	8,034
Africa	50	75	80	370	660	660	100	237	237
Oceania	30	30	30	5	85	85	15	94	94
North America	510	510	510	2015	2140	2,140	1323	2,014	2,102
Latin America	170	224	224	174	293	495	173	500	1,310
	3272	3870	4181	6463	9913	10,359	5503	12,171	17,523

[a] Excluding Russia and Communist Asia.
[b] Includes ammonium sulfate and ammonium sulfate nitrate.
[c] Includes ammonium nitrate (33%) and ammonium nitrate - limestone (20 to 26%).

Ammonium sulfate capacity increased by about 18 percent from 1967 to 1971, and a further 8 percent increase is expected by 1975. Much of this capacity is byproduct from coking operations, caprolactam production, and other industry.

Ammonium nitrate capacity increased over 50 percent from 1967 to 1971, but little further increase is planned. Urea capacity increased 220 percent from 1967 to 1971, and plans for further increase of about 44 percent have been announced. These capacity estimates include materials for industrial use. They probably include urea for use in solutions and complex fertilizers in many cases.

It appears that urea will be the leading form of nitrogen fertilizer by 1975. This is particularly true in Asia, Africa, and Latin America where urea is expected to constitute 62 percent of the nitrogen fertilizer capacity.

Although urea is the fastest growing nitrogen fertilizer many improvements still remain to be made that will no doubt make it even more popular.

Improvements in Physical Properties

The most common form of urea for fertilizer use is prilled material. These prills are generally small--most falling between 1.0 and 1.7 mm as compared to the common size of 1.4 to 2.8 mm for granular fertilizers in the United States and 2 to 4 mm in most European countries.

Disadvantages of Small Urea Prills

1. Increases tendency to cake and moisture adsorption
2. Requires heavy conditioning
3. Segregates in blends with other materials
4. Fragile--disintegrates easily
5. Poor spreading characteristics in spinner type applicators

It now appears that technology may be forthcoming to overcome these disadvantages. Cominco of Canada is producing a larger than normal urea by spray drum granulation. Two sizes are being produced--one size, about 1.7 to 3.3 mm in diameter is useful for direct application and in bulk blending. A larger size, about 4 to 6 mm, is used for forest fertilizer.

TVA is developing a pan granulation process that appears to be successful in producing well-rounded evenly sized granules. Three sizes have been produced.

2.4 to 3.4 mm for bulk blending and direct application

2.8 to 4.0 mm coating for controlled release

4.0 to 6.0 mm coating and forestry fertilization

Either process appears to go a long way in overcoming the disadvantages noted previously. These products are less hygroscopic and caking problems are reduced; they require less conditioner; segregation from blends is overcome; crushing strength is about twice that of air-prilled urea; and spreading characteristics better match that of other fertilizers.

Coating and Conditioning Improvements

Although some urea is marketed without conditioner, most is conditioned with finely divided inert dust such as kaolin clay or with one of several organic materials. These treatments are generally effective in preventing caking when handled or stored under moisture-proof conditions or bags, but none of these treatments is effective in retarding moisture absorption when the material is in contact with humid air above the critical relative humidity, which is about 75 percent at 30°C.

Coating to Retard Moisture Absorption

For hot, humid climates there is need for a conditioning treatment that will significantly retard moisture absorption. TVA has had relatively good success with the use of a petrolatum-resin-paraffin (PRP) coating. About 2.5 percent PRP coated on 1.7 to 3.3 mm granular urea reduces the rate of moisture absorption to one-fifth that of uncoated urea. Numerous other coating materials are being tested in an effort to identify low-cost, effective treatments.

It is also reported that the Dutch State Mines has developed an effective oil coating that will slow the absorption of moisture.

In all coating, larger granules are helpful because the smaller surface area per unit of weight reduces the quantity of coating materials.

Coating for Controlled Release of Nitrogen

We at TVA have been working with and talking about sulfur-coated urea for several years and I must mention it again here because of its potential influence on fertilizer marketing.

Development of a practical, economical method for controlling the release of nitrogen fertilizers has been the subject of research for many years. Generally, two approaches have been used: a search for suitable nitrogen compounds that are inherently slowly soluble and the coating of soluble compounds to reduce their solubility.

We have studied both approaches and believe the most promising one is the coating technique. The most promising coating system involves coating urea with sulfur and sealing the coating with an oily wax. A small amount of coal tar can be added to delay attack by soil microbes on the coating.

We have found that prilled urea is not very satisfactory for this use because of its small particle size, which gives a large surface area. It, therefore, requires a larger amount of sulfur for a given coating thickness than do the larger size materials such as the granular urea I mentioned earlier. So most of our work has been done with the granular material.

By varying the coating thickness, both the initial rate and continuing rate of nitrogen release can be varied to suit the crop and climatic conditions. Assuming a total coating weight of 22 percent, which might be about the average requirement, we estimate the cost of coating in a 500 ton/day plant would

be $14.50/ton, including 15 percent return on the investment. Assuming a price of $70/ton for urea (46% N), the estimated price of coated urea (36% N) would be $69/ton, or about 26% more per unit of nitrogen.

What are the advantages that might make this a marketable material despite the higher price? Agronomic tests gave the following results.

1. A single application on coastal bermudagrass gave results as good or better than four split applications of ammonium nitrate.
2. Luxury consumption of nitrogen was avoided.
3. A better distribution of protein was realized throughout the period of forage growth.
4. The sulfur residue oxidize slowly to plant available sulfate.
5. Heavy surface application to grass did not cause burning or loss of N through decomposition.
6. The sulfur-coated urea resisted leaching in cases of heavy rainfall and resulted in higher yields.
7. Response on rice grown either with intermittent or delayed flooding have been uniformly excellent.

In summary, SCU shows promise from an agronomic and also an economic standpoint on long season crops where split applications are the normal practice, on rice where continuous flooding is not practiced and on a wide range of sandy soils where leaching losses are heavy.

The technique for production of sulfur-coated urea has been successfully demonstrated in a small plot having a capacity of 300 pounds per hour. Recently, a larger pilot plant having a capacity of 1 ton per hour was built to provide larger quantities of product for agronomic testing and to provide opportunity for further refinement of the process. Tests are now

in progress in 36 states and in some 22 different countries. It is my opinion that SCU may actually be made in such countries as Taiwan, India, and Canada even before it is made commercially in the United States.

We are finding, however, that the requirements to obtain controlled release under all climatic and crop conditions are not uniform. For example, a product that gives the desired control on upland crops often supplies nitrogen too slowly for rice grown under paddy (anaerobic) conditions in the same geographical area. Also, the products break down more rapidly in soil or water as temperature increases. Therefore, it appears that to be successful SCU must be tailored to meet a specific set of soil, climatic, and crop conditions.

On the other hand, we have a good measure of control through merely altering coating weights. Also, the mixing of coated and uncoated urea would be a method of overcoming variations in release requirements.

Another advantage that may be obtained from SCU is that it can be utilized more freely in blends as tests to date indicate that the reactions between urea and superphosphates do not occur at any appreciable rate.

Urea-Ammonium Sulfates

Work on these products has been carried out primarily for the purpose of finding a way to utilize byproduct ammonium sulfate which is available, but in poor quality, at low cost at many locations. The inclusion of ammonium sulfate with urea supplies nutrient sulfur, which is needed on many soils. It also produces a granule that is much harder than one made from urea alone.

Processes have been worked out at TVA to combine two products either through granulation in the pan granulator or oil prilling. Finished granules (2.4 to 3.4 mm) containing 30 to 40 percent nitrogen and 4 to 13 percent sulfur

have been made successfully by varying the ammonium sulfate content from 20 to 50 percent of the total weight. These products, however, have low critical humidities; thus, conditioning will be required.

This approach shows promise as a means to market low-grade ammonium sulfate, add sulfur to urea, improve the granule strength of urea, and overcome to some extent the degradation problems with urea prills.

Use of Urea in Compound Fertilizers Containing Superphosphates

TVA has worked on processes to utilize urea with superphosphates in making granular compound fertilizers primarily because there are superphosphate plants in many developing countries that are not being fully utilized or are in danger of losing their markets because other more attractive fertilizers were becoming available. Superphosphate production is a simple process, and often may be the best means for utilizing byproduct sulfuric acid when the quantity is insufficient for larger and possibly more economical production.

The granulation of superphosphates with urea and other nitrogenous and phosphatic materials offers a means of providing good quality compound fertilizers that are adapted to the needs of the crops and the soils in a localized area. From a marketing standpoint it provides an improved quality material and a measure of diversity of production that may permit even small superphosphate plants to continue to contribute to an economy. Typical grades that can be made would include: 14-14-14, 10-20-10, and 8-16-16. Of course as grades go up the amount of superphosphate used is decreased.

Urea-ammonium Phosphates

TVA is now preparing a demonstration scale plant to produce various grades of urea-ammonium phosphate. Grades as high as a 30-30-0 or a 20-20-20 can be made with pure urea and pure diammonium phosphate or ammonium polyphosphate.

When using ammonium phosphate prepared from typical wet-process acid 28-28-0 and 18-18-18 are easily attained, even when allowances are made for conditioner.

UAP provides about the ultimate using present technology in making high analysis of 1-1-0 grades of fertilizers. Many different choices of process are available to utilize ammonium phosphate during granulation as a slurry, a solid, or a melt. Likewise, the urea may be used as a solid or a highly concentrated melt solution.

UAP is known to be commercially produced in both Japan and India. No plants are yet functioning in the United States.

Urea-Rock Phosphate

Under certain soil and crop conditions rock phosphates with high citrate solubility continue to show good response in comparison with other sources such as triple superphosphates.

We have attempted to granulate these rocks to overcome some of the difficulties and inconvenience of handling and applying finely ground rock. In doing so, we have found that the granulation with urea makes a very satisfactory product. It also permits the application of both nitrogen and phosphate at the same time. Although these granules are quite stable for handling and distribution purposes, they break down very rapidly once applied to a moist soil again giving the fine particles that are necessary for the best utilization of rock phosphates by plants.

Such grades as 26-13-0 and 18-18-0 have been made with high-grade rock phosphates and urea. We recognize that at present the potential of these products is quite small but where rock phosphate shows promise this is a method for overcoming the objectionable properties of rock.

Trends in Phosphates

Polyphosphates are continuing to grow in popularity and use in the United States, primarily in liquid fertilizers. Technological improvements that greatly simplifies their production should further increase the use of liquids.

Dry ammonium polyphosphates--12-58-0 to 15-62-0, depending on the purity of the acid--are proving to be very good fertilizers. They are completely water soluble and nearly all produced in the United States are being used to make liquids. It also appears that when our demonstration scale plant comes into production the main product will be urea-ammonium polyphosphate--a product useful both as a dry fertilizer and for the production of high-quality liquids.

The direct application of phosphoric acid is beginning to receive some real interest. Something over 60,000 tons are now applied this wa, in the United States. The acid can be used in ordinary non-corrosive liquid applicators. One specialty use is for vegetables grown on saline soils where crusting is a problem during germination. By applying phosphoric acid to the surface and over the row after seeding crust problems can be overcome and better germination assured.

Fluid Fertilizers

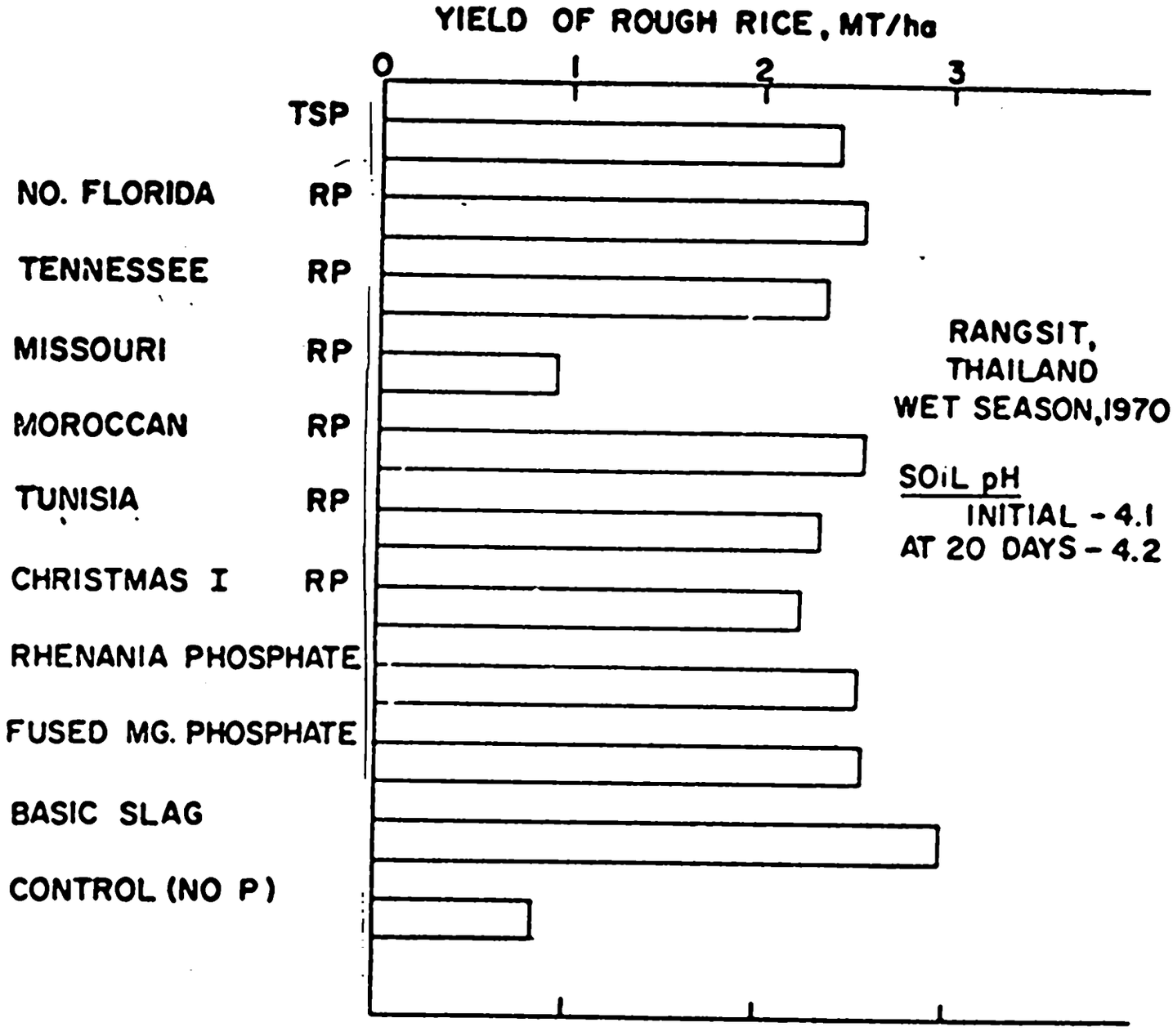
Fluid fertilizers continue to grow in popularity in the United States and interest is picking up in other countries. A development within the last year may significantly advance their use both in the United States and even more so in other countries. It is that a simple method for direct production of very high-polyphosphate (80 to 90%) 11-37-0 from wet-process superphosphoric acid of very low polyphosphate content and ammonia. This process, worked out in our pilot plants this year, uses the heat of ammoniation to generate polyphosphate in a simple pipe reactor. The advantages are both high sequestering power, due to the polyphosphate content, and low material cost, due to the use of low-strength super acid. The method is relatively simple and thus should be adopted promptly by industry.

Additional improvements are being made in suspensions. We have been working on high-analysis suspensions such as 13-41-0 and 14-47-0 and on suspensions of different materials. For example, we find that highly concentrated stable suspensions of limestone, sulfur or urea can be made. These too may become part of the market line of fluid fertilizers in the seventies.

Present Efforts May Not be Doing the Job on Phosphates for the Tropics

On the whole problem of new phosphate fertilizers, I am not convinced that the work on technology being done in the temperate climates is producing results that will be applicable to the tropics, especially to soils high in iron and aluminum. I feel that a whole new look at this problem is justified.

Today's popular fertilizers--the superphosphates, diammonium phosphates, nitric phosphates, etc.--are not showing the expected response. Often, such products as rock phosphates with high citrate solubility, hyperphosphates, fused magnesium phosphates, etc., give results equal to or sometimes slightly better than the highly water soluble phosphates. This is illustrated from some cooperative work in Thailand on rice grown in very acid soils.


YIELD OF ROUGH RICE, MT/ha
0
1
2
3
TSP
NO. FLORIDA RP
TENNESSEE RP
MISSOURI RP
MOROCCAN RP
TUNISIA RP
CHRISTMAS I RP
RHENANIA PHOSPHATE
FUSED MG. PHOSPHATE
BASIC SLAG
CONTROL (NO P)
RANGSIT, THAILAND
WET SEASON, 1970
SOIL pH
INITIAL - 4.1
AT 20 DAYS - 4.2

Similar results have been reported from high-aluminum upland soils in other parts of the world where liming materials are not available or are too costly to bring the pH to the range (6.0 or above) where water soluble phosphates function best.

I would think that for a country such as Brazil, where many of your soils are high in aluminum and liming materials are so costly, some basic research on new types of phosphatic materials to fit these needs might prove quite useful. Should you be successful in establishing your new technical center I would think this should be one of the priority projects that is considered.

Micronutrients

There are few new developments in this field. In the United States, fluids are being used successfully to carry micronutrients in many cases. Work is continuing to attain better incorporation in dry materials.

We do have indications, however, that for rice the type of compound may not be as critical as for upland crops. For example, oxide forms, which are generally cheaper, seem to be as good as the sulfate forms. This is especially true of zinc.

Future Ultrahigh-Analysis Products

To this point, I have talked about products that may come into the marketing picture in the relatively near future. We at TVA are also working, with some promise, on more advanced products. We have made what we now refer to as ''exotic'' fertilizers such as ammonium trimetaphosphate (14-73-0), phosphoryl triamide (45-75-0), and phosphonitrilic hexamide (55-92-0). These products have been proven to be perfectly satisfactory agronomically. Since they have so far only been made in laboratory quantities much additional

work remains to be done before we know how to make them technically and in commercial quantities at economical prices.

I mention them only to emphasize that we probably have not yet approached the upper limits as far as new products and high-analysis are concerned.