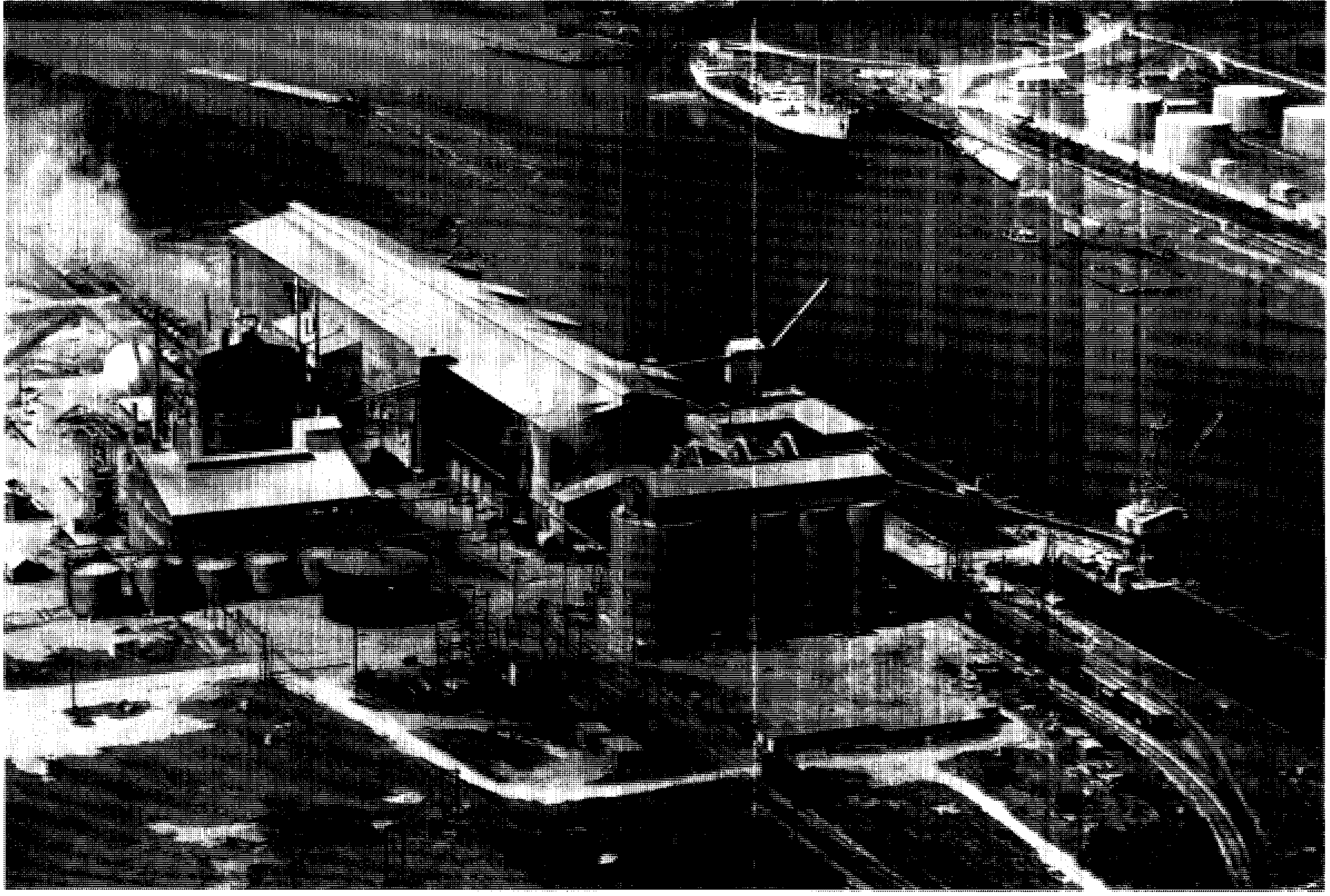

Once a lowly, despised scavenger business, the fertilizer industry is now a strong, respected member of the heavy chemical industry

Problems of the Fertilizer Industry

Introduction

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Among the associated agencies and industries servicing agriculture, many lack information about the peculiar problems which they engender directly or indirectly in the fertilizer industry. Consequently, it is not always possible for them to consider these problems in a sympathetic spirit. For example, agricultural extension workers, federal and state, know the benefits that can be derived by applying fertilizers to soils; but how often do these same advisors and teachers realize the difficulties their fertilizer recommendations make for the manufacturer?

Many, if not most, of the problems can be solved or alleviated by the combined efforts of industry and agricultural workers when there is developed a favorable spirit of "give and take." The discussions that follow deal with the technology, research and development, and business phases of the general theme: "Problems of the fertilizer industry related to agriculture." Their aim is to promote better understanding on all sides.

From the technological point of view, a veritable revolution has taken place in the fertilizer industry within the past 25 years. Once a lowly, despised scavenger business, it is now a strong, respected member of the heavy chemical industry. Some idea of its importance can be formed from a consideration of its size and productive capacity. Briefly, in the past fiscal year the industry produced a grand total of about 22 million tons of fertilizer valued at over $1 billion. It produced about 4.8 million tons of synthetic ammonia; it mined about 14 million tons of phosphate rock, from which it produced 4.6 million tons of phosphatic fertilizers on a P_2O_5 basis. Its potash score was 1.9 million tons as K_2O equivalent. In the production of phosphatic fertilizers it consumed over 4.0 million tons of sulfuric acid (100% H_2SO_4). It employs 39,000 workers of whom 29,400 are production workers, earning an average weekly salary of $73.39.

In research and development, the industry's effort has not been much different from that in agricultural agencies—that is, it has been directed chiefly to trouble-shooting, and scarcely at all to fundamentals. Much knowledge has indeed been accumulated and much has been achieved, but too much of it is concerned with short-range problems. Future progress will not be promoted significantly by solving such problems.

What is really known about what happens in the plant tissues when nutrient elements are absorbed through the roots or the foliage? What really occurs at the root tip and along root hairs in the process of plant nutrition? Do roots also absorb molecules, organic and inorganic? What is the ionic balance pattern in the rhizosphere as different nutrient elements are introduced into it as fertilizers? How do these patterns affect the root system and the enzymatic patterns within the tissues associated with such nutrient levels in the soil?

Agricultural research in the past has emphasized ways and means of influencing crops to yield more. Yield increase has been the measuring stick for evaluating research projects. But this puts research out of balance. The big research task is to find logical, realistic explanations of why plants respond as they do. Such basic research will build a firm foundation for future progress.

From the business point of view, the industry has many ulcer-engendering problems, related in most cases to a disparity between productive capacity and actual sales.

During the past five years—1952–58—the productive capacity of the industry has steadily increased from a rated capacity of 27 million tons to over 30 million tons of mixed fertilizers and materials. In that same period the total sales tonnage declined about 4.5% and in fiscal 1958 the estimated total dropped about 8%.

In this same five-year period the productive capacity of synthetic ammonia for agriculture increased from about 1.5 million tons as N to a rated capacity of over 3 million tons. Real capacity is about 25% greater.

The productive capacity for phosphate in 1952 was about 3.6 million tons, basis P_2O_5; in 1958, it was 4.6 million tons.

As to potash, in 1952 the productive capacity was about 1.7 million tons, basis K_2O. In 1958, it was 2.7 million tons and the prospect is additional potash supplies will be coming into the domestic market from Saskatchewan within a year or two.

During the 1952–58 period the industry experienced increases in the prices of goods and services and labor—labor cost increased by 31%, freight by 30–35%, and all other items proportionately. Meantime gross profit margins were steadily squeezed and many of the cost increases were absorbed by the manufacturer.

These are some of the headaches that constitute fertilizer industry problems.

Technological Problems

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THE fundamental common objective of the fertilizer industry, the state agricultural colleges, the experiment stations, and other public agencies is to help the farmer obtain maximum economic return from the use of plant food. Progress toward this objective will be hastened if the farmer and others concerned learn more about the viewpoints and problems of the fertilizer producer. Not the least of these problems are technological ones, with roots in the principles and practices involved in the formulation and manufacturing of fertilizers.

Fertilizers are added to the soil to provide a more nearly optimum supply of the 15 or more elements required for plant growth. Fortunately, most agricultural soils in this country contain appreciable amounts of all of the inorganic elements required, and many of the elements are very seldom deficient. However, three of these elements are very frequently present in the soil in amounts suboptimum for plant growth. These are nitrogen, phosphorus, and potassium, the so-called major fertilizer elements.

Another category of essential elements—calcium, magnesium, and sulfur—is referred to as secondary elements. The third category is referred to as trace elements, and several of them are the same as those required for animal growth.

A wide variety of ingredients or carriers is used to supply the necessary elements.

There is hardly such a thing in existence as a typical fertilizer plant. The manufacturing plants vary in size, degree of modernization, processes used, and other factors. There are, however, certain general operations and classes of facilities that are common to the majority of fertilizer plants. All fertilizer plants, even the simplest, have certain accessory operations for the handling of materials and the storage of ingredients and finished products.

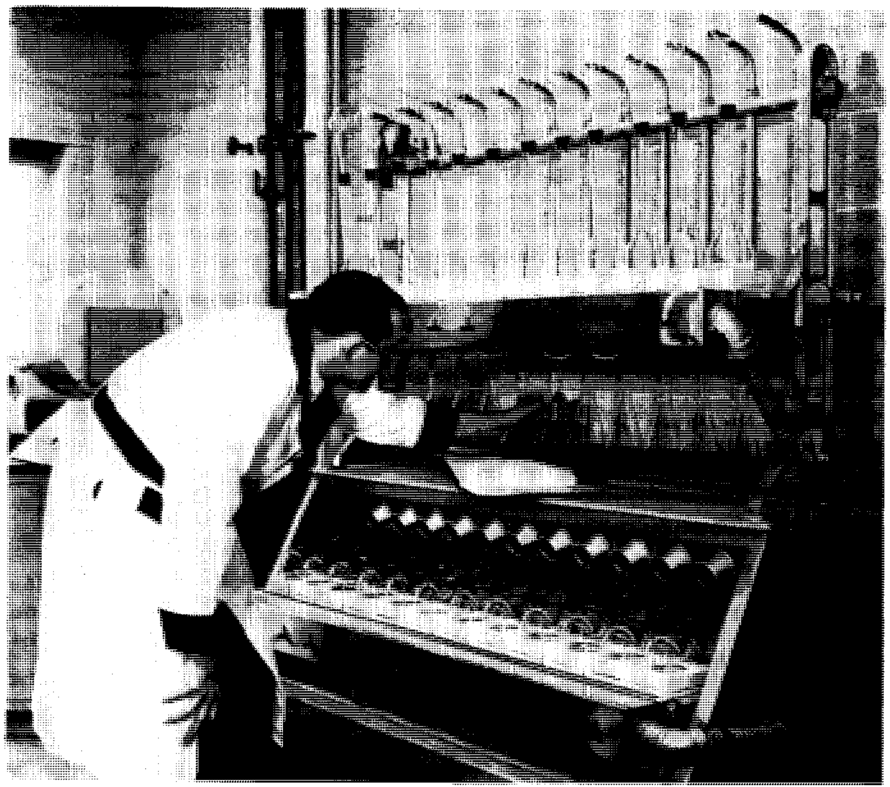
Blending Is the Heart

The blending of solids and liquids to produce homogeneous mixtures of predetermined grades is the heart of the fertilizer manufacturing process. In the final blending operation, both simple ingredients and the so-called base mixtures may be used. Base mixtures are intermediate preparations made by a prior blending of two or more of the more troublesome ingredients of fertilizers.

This deceptively simple description may lend the impression that the problems of the fertilizer manufacturer are few and minor. This, unfortunately, is not the case. Since its beginning about 1850, the fertilizer industry has witnessed an almost complete change in its raw materials. This has changed the mixing of fertilizers from an industry which blended large quantities of by-products and waste substances, such as organic ammoniates, with manure salts and superphosphate, to one of the largest chemical industries in the world. These changes have brought many physical and chemical problems to the industry. For example, double decomposition reactions which occur when certain widely used plant nutrients are blended in powdered form can cause caking and hardening of mixed fertilizers.

Without doubt, more problems in

The fertilizer industry must cooperate with allied industries to solve some problems. It works with farm equipment companies on better application equipment



Keeping on grade is a big problem for fertilizer manufacturers. If a product analyzes above guarantee, money is lost. If it is below the guarantee, prestige is lost

the manufacture of fertilizers are associated with the physical properties of the finished product than with any other factor. Ideally, finished fertilizers should be free flowing, free of caking or lumps, non-hygroscopic, free of dust, and easily distributed in the conventional implements used by the farmer. In addition the mixture should be uniform—that is, the ingredients should not segregate during mixing or subsequent handling. Meeting such specifications provides the manufacturer with a major share of his technical problems.

In order to prevent caking or lumping, the manufacturer must exercise care so the ingredients he uses are properly cured. The chemical reactions between ingredients should be completed before the final product is bagged. He must also exercise great care in the final moisture content of his product. Use of some of the nitrogen solutions and the necessity for producing higher analysis mixed fertilizers have complicated this problem.

Another problem which may be classed as physical is segregation of materials. Segregation may take place when the mixture is poured from overhead bins and during screening and bagging operations. It may continue during transportation to the consumer and while the product is being distributed on the farm. If all components of a mixture had the same range of particle size, segregation would be of little practical consequence. However, when one component consists of large particles and another component of small particles, segregation becomes a serious problem. Segregation naturally increases the problems of sampling and quality control.

The fertilizer industry has been well aware of its responsibility to produce finished products having suitable physical properties. The steps taken to solve this problem include better curing of superphosphate and other base goods, better formulation to avoid undesirable reactions, and use of more granular ingredients. But perhaps the greatest single step forward in recent years has been the adoption of granulating techniques to produce coarser finished products. It is possible to produce granular materials having a reasonably uniform particle size and a suitable uniformity in chemical composition. In general, granular products store well for long periods without caking. Segregation is reduced, although not necessarily eliminated. Granular products also have good drillability, permitting the farmer to make uniform distribution in the soil.

There are several techniques for granulation of fertilizer. In this country, however, it generally involves the addition of moisture to the finely divided mixture by means of ammoniating solutions, water, steam, or acid. The moist mixture is rolled or tumbled until granulation occurs, or it is put through a pug mill, and the granular product is then dried. The dried product is sized by screening; fines are returned to the granulation process and oversize material is reduced to a suitable size.

Expansion of Granulars

In the last four years sales of products in granular form have expanded sharply. The share of the market obtained by granular products has been greatest in the North Central area, where it may be greater than 50% of the total. It is least in the South Atlantic area where only a very small percentage is involved. In view of customer acceptance of this form of product, undoubtedly the trend toward granular goods will continue.

The production of granular fertilizers in itself presents certain problems to the industry. First of all, of course, is increased cost of production. More equipment is required, and more capital. More skill is necessary in the operation, and the selection of ingredients is more limited.

Another of the serious problems which many fertilizer manufacturers face is the production of a multiplicity of grades. In the intelligent use of fertilizer, the grade required varies with the crop, the soil on which it is grown, and other cropping practices. There is no one grade or one ratio which is satisfactory under all conditions.

However, it is possible to overdo a good thing. A few years ago it was estimated that more than 900 grades of fertilizer were being manufactured in this country. There are single plants in this country which in a given year may produce more than 150 different grades. This greatly complicates all operations. Storage, materials handling, formulation, record keeping, and plant efficiency are all adversely affected.

Production of so many grades of fertilizer is neither essential nor desirable. Not only does it affect manufacturing efficiency and profits, but it also indicates that the farmer is not making the most efficient utilization of his fertilizer. It is impossible to predict the nutrient requirements of crops so closely as to require formulation of so many grades. Environmental and other factors such as rainfall rule this out.

In recent years, there has been a trend downward in the number of grades produced. There is a great need to accelerate this trend. Achievement requires the close cooperation of the industry and the public agencies responsible for making fertilizer recommendations to farmers.

There is another area of fertilizer technology in which considerable progress has been made, but which has brought additional problems. This is in the production of fertilizers having a higher content of plant food. In its early days, the industry used raw materials such as organic sources of nitrogen and low grade minerals that contained a relatively low content of the essential plant food elements. It was impossible to formulate grades carrying a high plant food content with such raw materials. As these organic sources of nitrogen were gradually replaced by inorganic nitrates, ammoniacal compounds, and urea, and as the technology of minerals beneficiation advanced, the fertilizer industry acquired raw materials of higher plant food content. Today, grades containing 30% total "primary" plant food are about average, and grades containing as much as 50% are not unusual.

The industry and educational institutions have cooperated to bring the advantages of high analysis fertilizers, such as lower costs per unit, greater ease in handling and application, and lower transportation costs, to the attention of the consumer.

Problems of High Analysis

But development and production of these high analysis grades has brought problems to the industry. First there is a limitation on the materials that can be used. High analysis ingredients are mandatory. Another problem is the danger of nitrogen losses, both in the manufacturing process and later in the storage. This creates the necessity for more careful formulation and careful control of the manufacturing process to prevent the loss of ammoniacal nitrogen. A third problem is the increased difficulty encountered by the manufacturer in making the proper grade without unduly exceeding the guarantee. It is much more difficult to achieve close control of the grade with high analysis fertilizers than it is with the lower analysis goods. Another problem involved in the production of high analysis grades, particularly when they are granulated, is the lower production rate. The rotary type ammoniator has a large recycle load, sometimes as much as five to six pounds of recycle for each pound of product.

The industry looks forward with certainty to the development of new raw materials containing even higher amounts of plant food. It will probably be particularly true in the case of the phosphatic materials. New sources of slowly available nitrogen also are being developed. With these advances in technology and new raw materials, the industry will be faced with new problems in formulating high analysis grades, particularly in meeting the diverse ratios sometimes recommended by the agronomists and the agricultural experiment stations.

Another problem of the fertilizer manufacturer falls in the fields of both technology and merchandising. The sale of fertilizer is strictly regulated by control agencies in each of the states. A control program is to the advantage of both the industry and the consumer. However, many people believe there is a need for modernization of the concepts which have developed around the registration of fertilizers.

In some cases, control officials are reluctant to permit registration, advertising, or promotion of materials and mixed fertilizers that go beyond the old concepts of a mixture of carriers of nitrogen, citrate-soluble phosphorus, and water-soluble potassium. However, the use of high analysis ingredients has reduced secondary element levels from those formerly found in mixed fertilizers. For example, the calcium content of triple superphosphate is much less than that of normal superphosphate; its sulfur content is negligible. The use of purified potash salts eliminates much of the magnesium formerly found in such products. Under present control regulations, phosphorus values may be claimed only on the basis of citrate solubility. Yet, there are instances where rock phosphates on the one hand and water-soluble phosphate on the other may have decided economic advantages to the farmer.

Perhaps the time is appropriate for careful review of our control laws in the light of new knowledge about plant nutrient requirements. Perhaps some revision of present day regulations would enable us to take fuller advantage of what is known about soil-plant relationships and various fertilizer ingredients. Again, the cooperation of the experiment station is essential to the success of any such program.

The fertilizer industry has a right to be proud of its record of service to American agriculture. However, some of the technical problems facing the industry have not been satisfactorily solved, and other problems will arise in the future which will require research and development work. The industry needs to depend less on others to solve its problems in manufacturing and technology. There is relatively little research going on in this country at the present time on fertilizer manufacturing technology. The Tennessee Valley Authority is most active in this regard, but other agencies of the federal government are not very active. Agricultural experiment stations, with one or two exceptions, have paid little attention to fertilizer technology. Some of the individual fertilizer companies are too small to support research and development programs of their own. This situation might be improved by the participation of the smaller companies in an industry-wide effort to support research and development.

For modern application equipment to operate most efficiently, fertilizer caking has to be controlled

The industry must also cooperate with allied industries in the solution of some of its problems. For example, it should work with the farm equipment companies in the development of better equipment for applying fertilizer to the soil.

Not Very Robust

The present economic health of the fertilizer industry is not very robust. Production capacity far exceeds demand, and price competition is exceptionally keen. In the field of technology, the industry must reduce its costs to an absolute minimum consistent with the production of products of uniformly high quality. Every avenue offering promise of lowering costs and increasing manufacturing efficiency must be explored. Greater efficiency and more service to the farmer—these are the industry's pledges to itself and to its customers.

Research and Development Problems

E. D. CRITTENDEN, Allied Chemical Corp., Hopewell, Va.

AGRICULTURE has progressed tremendously in all phases of plant and animal husbandry in the past century, particularly in the U. S. and Europe. The fertilizer industry, which exists to furnish plant foods for growing food, feed, and fiber crops, has shared in that progress. Developments in this industry, while perhaps not so phenomenal as some recent astronautical developments in other fields, have nevertheless contributed significantly toward providing and ensuring a rising standard of living here and abroad. Consumption of the primary plant food nutrients in the U. S. increased from under 2 million tons in 1940 to about 6.4 million tons in the 1956–57 season. These increases did not occur by chance but served a real and growing need. They further definitely presage a continuing increase in plant food consumption to meet the needs of a rapidly increasing population with ever fancier appetites.

The successful growing of plants, whether for useful or aesthetic purposes, requires among many things three major factors:

- High quality seed or nursery stock
- Proper nutrients
- Proper protectants

There is an increasing tendency for the proper nutrients and the proper protectants to be furnished in single packages by single suppliers. This trend will continue to grow as more is learned about compatibility of ingredients.

What problems lie ahead for research and development in the fertilizer industry? To furnish a basis for planning ahead constructively requires careful evaluation and orientation of the present situation as to materials, forms, and practices in agriculture.

The principal plant foods furnished by the fertilizer industry today are supplied by a surprisingly small number of compounds compared with the total number appearing in chemical dictionaries. In the case of nitrogen, for example, a mere dozen or so compounds furnished all of the more than 2 million tons of nitrogen used in the United States in recent crop years. The same holds true for phosphate and potash. This augurs well for the future, because it says that almost myriad possibilities exist for making specific new materials and combinations as agronomists and plant scientists demonstrate the need for them.

Future food, fiber, and feed crops will come principally from four main sources:

- Present crops
- Improved plant varieties and hybrids
- New crops under development
- Other sources such as oceans, seas, and lakes.

The common goal of agriculture and the fertilizer industry is the growing of ever larger crops of ever better quality by the use of more plant food, over-all and per cultivated acre. Corn is an outstanding example of a crop which through hybridization, higher population per acre, and increased use of plant food has produced phenomenal results. In one test in 1956, a yield of 203 bushels per acre of corn containing about 11% protein was obtained in a field across the fence from one which produced only 35 bushels per acre and 7% protein. The difference in yield and quality lay in this case in the feeding.

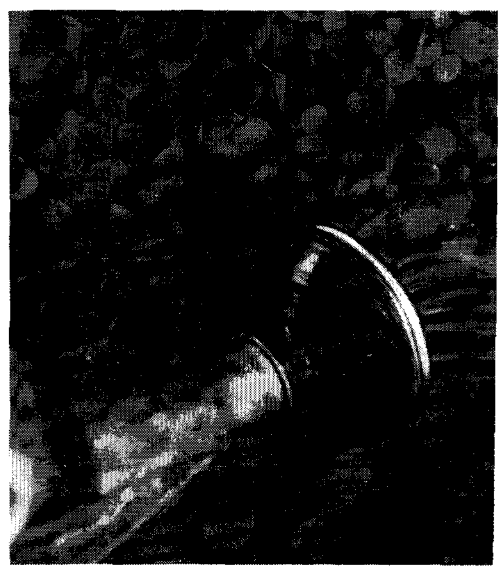
Examples from other crops and from pasturage are abundant, all showing equally startling results. Through such practices, the over-all acreage available for food and fiber production is being figuratively enlarged by millions of acres. What has been done in isolated plots or areas is possible generally in the United States and throughout the world; it is an encouraging answer to critics who predict an ultimate food shortage as population increases. From the gross standpoint the conclusion must be that ever increasing quantities of plant foods will be needed.

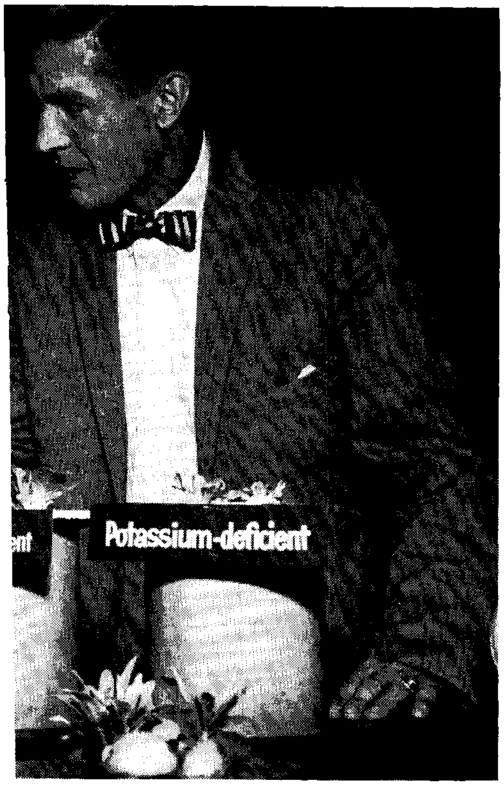
The use of water in proper quantity and at the right time throughout a crop's life is another keystone. Who can say today what outstanding over-all results would come from the optimum use of water on our main food crops? Indications of the large beneficial effects that might accrue are available from limited tests with truck and garden crops, and especially crops such as tobacco.

A few years ago it was demonstrated that urea could be used as a plant food by spraying a dilute water solution onto the leaves of certain plants and trees. Unfortunately some adverse results, due to the presence of biuret in the commercial urea used, were obtained with citrus and pineapple crops. Since then, through research, the fertilizer industry has learned how to produce urea in good physical form with low biuret content, and the bad impression caused by the adverse results is gradually being overcome. *Foliar feeding stands out as* a milestone in agriculture, and additional practice is bound to occur. Many other materials, including new ones, can doubtless be used in this

Communications—the big problem in the fertilizer industry. Many notable attempts have been made to bridge the gap between science and the layman, such as this TV show in San Francisco, where an NPFI staff man explained how important all plant nutrients are

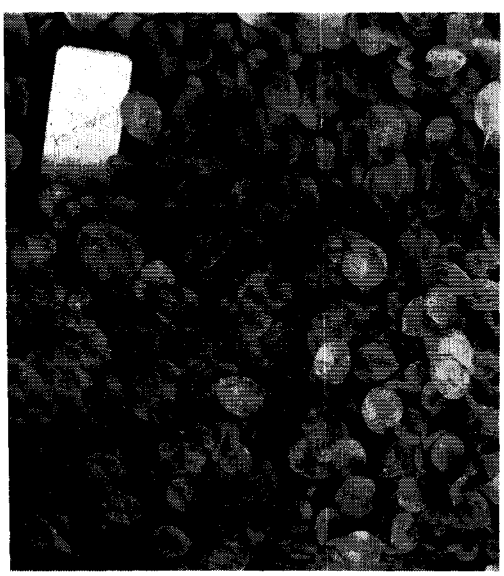
Foliar feeding stands out as a milestone in agriculture





same manner, and the plant food industry stands ready to supply these as the need is shown.

Related broadly to foliar feeding are the outstanding results obtained in plant culture through the use of hormones and growth promoting substances not in the category of the usually recognized plant foods. Gibberellin is a prime example of such materials and the full commercial significance of this product of scientific research has not been realized. At this point, the chief prospect for the fertilizer industry lies in the fact that more plant food will be required if extensive use is made of such a Jack-and-the-Beanstalk development.



Quite recently new systemic pesticidal materials have appeared on the market. Placed in the soil around plants or trees, they are taken up through the roots and travel in the plant juices to wreak havoc on aphids and mites on the leaves far from the point of ingestion. A highly significant angle of these systemics is the ability of plants to take them up unchanged and have them reach the leaves with undiminished toxicity. This furnishes strong evidence that molecules can play a prominent part in plant culture, and that ionic mechanisms, while existent, may not be all-important. The finding may have strong implications in the area of plant feeding.

Further evidence along the molecular line is found in the very recent announcement that a glycocide recoverable from asparagus can be sprayed on plant leaves, travel down to the roots and repel or kill nematodes. This work initiated at the University of Maryland is truly a milestone whose total significance is as yet not proved. While such developments do not always deal directly with plant food, they will certainly have an impact on fertilizer use.

Plant Feeding an Old Practice

Plant feeding by use of organic manures such as plant and animal residues is one of the oldest fertilizer practices, dating back at least to the time of the Egyptian pyramids and the early Chinese cultures. Synthetic organic nitrogen materials which furnish slowly available and non-burning nitrogen to plants are of very recent origin by this time scale. The best known synthetic materials today are chemical combinations of urea with formaldehyde. A range of products varying from those very low in solubility, like barium sulfate, to some that are quite water soluble can be made. Agronomic results to date show that it is readily possible to have rather water soluble materials which are nonburning to plants, opening up a whole new line of possible plant food products. More research is needed here.

Much more is known today about human and animal nutrition than about plant nutrition. In these areas, we are out of the meat, potatoes, bread, and pie era of yesteryear. Now people must have so many calories from carbohydrates, so many from proteins, so many from fats, all supplemented with the proper types and quantities of vitamins and hormones. In plant feeding, nitrogen, phosphate, and potash are equivalent to the meat and potato stage, and while much is being learned about the specific requirements of specific useful plants, only the surface has been scratched. Most is known about phosphate metabolism while much less is known about potash and nitrogen needs and metabolism. What an opportunity for enlarging basic research! Possibly we need "calorie" consciousness for plants.

Agriculture in the many phases dealing with the growing of plants must, for best success, be a team effort by farmers, agronomists, plant scientists, and the fertilizer makers and formulators. The fertilizer industry is a service industry and as such can attain its objectives only when the closest cooperation exists between it and those who use its products, together with those who recommend and control their use. From the standpoint of research and development, much has been accomplished in plant breeding and feeding but some of the recent findings, a few examples of which have been cited, open whole new vistas for thought and investigation.

Quite possibly a pound of plant food is not always a pound of plant food. In some cases its equivalent may be only one-tenth of a pound and in others it may be 10 pounds. Certain synergistic effects as well as toxic effects have already been discovered; the end is not in sight as more fundamental information is continually unveiled.

Business Problems

EDWIN COX, Chemist and Chemical Engineer, Aylett, Va.

Most of the fertilizer industry's business problems fall under the heading of communications problems. They are not impossible of solution, for communications between the fertilizer industry and control agencies and agricultural research groups can be improved. One of the most urgent needs is for a forum, such as the Agricultural Research Institute can provide, not only to aid the fertilizer industry with its many problems, but also to contribute to agricultural science.

There are language difficulties that impede communications. The word agriculture—the care of the fields—certainly embraces the industry producing fertilizing materials. Yet there is some evidence that the language used by the fertilizer industry is not the same as that used by the rest of agriculture. At the 1958 National Plant Food Institute meeting there was a plaintive cry by one industry man to the effect that "over 50% of farmers do not even grasp the terms used to describe fertilizer." Better results would surely have been obtained if the industry had been addressing farmers in their own language. Improved communications with farmer and agricultural scientist will improve the business outlook of the industry.

Overcapacity

Overcapacity is an industry problem. Some five years back, Defense Production Administration and National Planning Authority directives had established minimum capacity objectives to meet estimated minimum fertilizer requirements. The industry constructed the indicated capacity. But the requirements have not developed. The requirement for available phosphates was set at 3.6–3.7 million tons by 1955. From 1952 through the crop year 1957, however, the requirement hovered between 2.2 and 2.3 million tons. Existing surplus capacity in primary plant nutrients has been estimated at up to 90% in phosphates, 70% in nitrogen, and 40% in potash.

Forecasting is fun. But it is dangerous when the fine print isn't read. The predicted pressure of population on food supplies has not developed. The decision to admit the 49th state was made, finally, not to give this nation the added area required for food as so popularly proclaimed a few years ago, but for other considerations. Indeed, the nation's problem now (AG AND FOOD, September 1958), is "the pressure of food supplies on the population." In the spring of this year an under secretary differed with his department's estimates on food requirements for the next decade by between 25 and 30%.

The National Planning Association has forecast that with rigid controls a balanced agriculture can be attained by 1965. But to do this the farmer's halo of independence will be worse than tarnished. He will have to submit to farming by decree; the forecast does not allow applying the accelerating progress of the agricultural sciences.

But if balance is desired, farming by decree is necessary. Unfortunately the decrees and their givers change. The fertilizer economist facing these variables can cite the words of his Sibylene oracle "Yield not to disasters, but press onward the more bravely" or "The descent to Avernus is easy." More often he reconciles himself to

Optimum usage of the fertilizer industry's products remains too much an art, not enough science. Even the soil test cannot always be adequately evaluated

the conclusion that the laws of supply and demand are archaic, and remembers the words of the late General George Patton: "You can't push a piece of spaghetti."

Controls are irksome, both to individuals and to industries. But they are necessary. The fertilizer industry confronted with farming by decree has little control over its market, but is burdened with many controls of other kinds. Indeed, as John D. Conner, counsel for the National Plant Food Institute, has said, "few industries are subjected to more extensive and labyrinthian control . . ." Labyrinthian is the legal light touch.

Herein communications can solve many problems by establishing rapport among the control agencies. There are regulatory agencies of all the states; the various associations, AAFCO, AOAC; the experiment stations, extension services, Agricultural Stabilization Committees; some agencies of the USDA; other federal agencies. There is not always unanimity. Each exercises regulating powers directly or indirectly.

Existence of the Miller Amendment and the new Food Additives Law, with responsibilities divided between federal agencies, and the struggle with the question of where state control starts and stops do not simplify the problem. To complicate matters further, there has been a 100% increase in fertilizer-pesticide admixtures in less than two years. Systemic pesticides present another problem. And will potassium gibberellate fall under state or federal control? Urea-formaldehyde concentrates as forms of slowly available nitrogen are plant foods—but they are also good for potato scab. How should they be classified and controlled?

Grades are established by states. They are local matters. Conferences on fertilizer grades are often based on neither science nor art, but fall strictly under the classification of trade meetings

By 1960, the American Association of Fertilizer Control Officials hopes to have the P and K of NPK denoted on an elemental basis. No approach at all has been made to the question as to how to regulate some secondary and trace elements. It is reported that there is a difference of opinion and a breakdown in communications on this subject, too. Mediation may rest in the halls of the several legislatures.

Sampling is a control problem. The problem of eliminating bias in sampling thousands of different mixtures of varying physical condition and under different conditions of storage in the field is tremendous. Bulk distribution and the production of granular and pelletized, high analysis, and liquid forms of fertilizer have complicated the task. Overages in formulation are expensive; deficiencies bring on fines and, more important, loss of prestige. Solution of this problem would be pleasant and profitable to the industry.

Methods of analysis have become not only an irritant but an itch. W. L. Hill of the USDA has stated in AG AND FOOD (February, 1957): "Establishment of criteria of quality is the principal task in the nutritive evaluation of fertilizers."

There are no adequate criteria today. To a high degree the industry's operations and the optimum usage of its products remain too much art, not enough science. Without even making allowances for varying crops or soils, testing laboratories contacted in a recent survey reported 234 variations in soil tests for a single nutrient element. There are not adequate means for evaluating many soil tests. Phosphatic fertilizers varying a thousandfold in solubility have been rated as equal. Convenience has often taken precedence over accuracy.

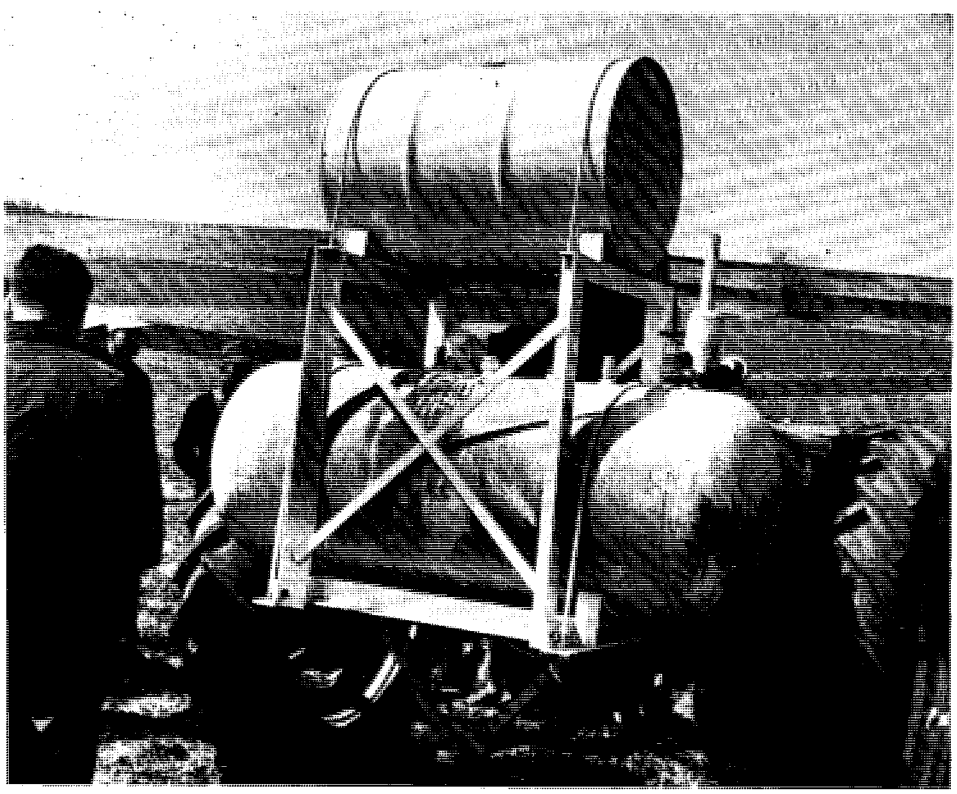
On this point the late E. M. Crowther of the United Kingdom wrote: "There is a great practical convenience in having a single universal test, but there is also considerable risk if it should fail for any important class of product or kind of soil." W. L. Hill and K. D. Jacob of the USDA have led in pointing out the pitfalls in seeking a universal test. There are five general methods in use in the world today for the analysis of phosphatic fertilizers. None is less than 50 years old. There is obviously room, and need, for progress. Meanwhile the farmer probably wisely ignores much of the nomenclature dating back a half century, and uses those products which he has found—by empirical methods, and in more recent years—to be profitable.

A forum on methods of analysis could well start with the work of Fresenius, Neubauer, and Luck of 1871 and follow through the Cincinnati/Washington controversy of 1880–84, as described by W. C. Jones in 1930 in his "History of Citrate Method." The participants did not know they were laying down the laws of the Medes and the Persians to the fertilizer industry.

Trends toward high analysis are continuing. Now the term is a relative one. The Paley Commission in 1952 hoped for a plant food average level of 28% combined NPK by 1975. In 1957 the national average was 29.54%. Is the mission accomplished? Hardly. What really is the objective? High analysis is a relative term. Phosphine has been pot tested; it would have a P_2O_5 analysis of 200%. Between the crop years of 1956 and 1957, the grade 6-24-24 increased 45%; 5-20-20 increased 10% to supply 5.5% of the total tonnage (not plant nutrients); 12-12-12 increased 22% to supply 4.5% of the total tonnage.

The fertilizer industry has hundreds of millions of dollars invested. The industry wonders and wanders seeking answers to high analysis problems. There are many questions of technology; most of them are matters of decision, such as: how valid is the so-called ideal nutrient ratio 5-1-1.7; if granular materials are necessary, what should be their hardness, size, solubility; how far should the industry go in deleting the secondary elements calcium, magnesium, sulfur; how can the salt effect be applied, other than in taking advantage of it in citrate solubility analysis; what are the limitations of distribution equipment?

New forms of fertilizer require new types of applicators



Problems of economics and of political economy take precedence over technology. In the spring of 1957 the Production Economics Research Advisory Committee recommended to the USDA a high priority research program to determine the economic effects of high analysis fertilizers on our agricultural economy. To date there is no known reported progress.

Secondary and trace elements are subordinated to the triumvirate NPK. At the 1957 meeting of the Agricultural Research Institute there were reports of "galvanizing" and "selenizing" of swine, and perhaps even "tantalizing." Zinc, selenium, and other minerals are nutrients that must be considered, and the fertilizer canvas of the future cannot be painted with only the NPK primary colors. Von Liebig's law that the chain of nutrients is only as valid as the weakest link holds true. Practical agriculturists have frequently explored ahead of our techniques for analysis. A striking example is that of John Lee Pratt, and the work he has fostered on trace elements.

Sulfur is essential to plant growth. Replenishment from the atmosphere varies one hundredfold from place to place. The erosion loss is high. Correcting of sulfur deficiency makes available soil phosphorus and nitrogen. The importance of sulfur in biophysics is recognized. The radioactive isotope is available for scientific studies. But sulfur now falls in a category with the weather, as described by Mark Twain—much talk, little action. With the trend to high analysis, should sulfur be squeezed out of formulations?

Average approaches to problems of the industry are as irritating as attempts to fit averages to the behavior of the individual. Mass Middletown methods do not answer problems. The fertilizer industry is essentially a local industry with crops, soils, and customs differing. More statistics related directly to local problems could better serve this industry in its efforts aimed at the maintenance of our soils.

In the old Three-I (Illinois-Iowa-Indiana) league there was some splendid baseball. The scores of its games were not as baffling as the paradoxes in the fertilizer game today. Iowa is one of the three largest states in fertilizer-pesticide admixture consumption. Illinois obtains 60% of its total phosphatic fertilizer from phosphate rock, while Iowa and Indiana consume only 4% of their P_2O_5 in this form. Indiana had the largest plant nutrient consumption of any state, 417,000 tons in 1957, and consumed 90% of that tonnage in 15 grades, but 130 other grades were included in the remaining 10% of the tonnage. The Mountain States region uses 88% of