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TRENDS IN FERTILIZER USE

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Introduction

The fertilizer industry in the United States has become a much more mature industry. Changes in technology continue to occur, but, major changes that would parallel such developments as the beginning of granulation, bulk blending, or fluids, aren't likely. Instead, they will be more subtle. Yet, they will affect the way fertilizers are made and sold.

I'm going to examine some of these changes and to try to predict how they will affect the fertilizer industry. I'll limit my remarks mostly to trends in engineering as they relate to fertilizer use because I am an engineer. I realize, of course, that agronomic or economic trends can't be separated from engineering trends because fertilizers and fertilizer manufacturing methods must be directed first by agronomics and eventually by economics.

Table 1 shows the distribution of fertilizer by percent in the United States for the past 8 years and for New York for 1976 and 1984 as reported by the Association of American Plant Food Control Officals-TVA (AAPFCO-TVA) (1). Survey data were not obtained from New York in 1979. Bulk blends and fluids have increased their overall market share at the expense of granulated fertilizer. The switch has been more dramatic in New York. Bulk blends increased from 18 to 57% of the market and fluids increased from 3 to 17% while granulated fertilizer declined from 65% to 7%. The AAPFCO-TVA survey shows that about 70 NPK granulation plants are operating in the United States. This is down from 108 in 1981 and about 300 in 1964.

Bulk Blends

Bulk blends continue to get an increasing share of the market because they are a convenient and versatile way to give the farmer exactly the fertilizers he needs at the lowest price. Imported urea and relatively inexpensive handling and mixing equipment are also affecting bulk blending.

Imported urea delivered into the Midwest is reportedly selling for $12 per ton less than ammonium nitrate. This means you can buy 46 units of nitrogen as urea for $12 less than 34 units of nitrogen as ammonium nitrate. Most blenders can't resist such a bargain. As most control officials will tell you, analysis problems continue to plague bulk blending, but use of imported urea, if it is not high quality, will create even more problems. Differences in particle size between raw materials are the major cause of segregation and subsequent poor analysis in bulk blends (2).

Adding micronutrients to blends also continues to be a problem. Micronutrients are becoming more popular in blended fertilizer. Although this trend may not have any agronomic basis, most blenders are adding micronutrients to fertilizer. The problem is created when blenders attempt to attach powdered micronutrients to fertilizer granules with oil or some other binder. The powdered micronutrient does not stick to the fertilizer granule very long and the binder tends to make the fertilizer difficult to handle and causes buildup on mixing and handling equipment. Granular micronutrients also are unsatisfactory unless a large quantity of the micronutrient is required.

Most mixers now coming on the market are units which combine the weigh hopper with the mixer. This saves money because it eliminates about one-third of the equipment needed to blend fertilizer. The efficiency of these new mixers, however, has yet to be proven. TVA has tested several mixers including a horizontal axis rotary mixer, a shaft-mounted rotary mixer, a concrete mixer, and a paddle mixer. All of them, when used properly, have produced surprisingly uniform blends.

Many bulk blenders, especially those near large cities, are beginning to blend and bag fertilizer for turf grass. These often contain slow-release materials, such as urea formaldehyde or sulfur-coated urea (SCU). There are now four producers of SCU in North America.

Granulation

The number of NPK granulation plants is declining. The tonnage sold by these plants also is dropping but not as fast as the number of plants. If ammonium phosphate (monoammonium, MAP, diammonium phosphate, DAP) plants can be considered granulation plants, the granulation system is alive and well; but ammonium phosphate plants are changing too because their market is changing. Most ammonium phosphate sold is still DAP but MAP is becoming established as the major raw material for suspension fertilizers. MAP gives fluid fertilizer manufacturers a phosphate source which is competitive with the phosphate source (DAP) used by bulk blenders. Many DAP plant operators believe that MAP is easier to produce than DAP using the same equipment. Because only one hydrogen on the phosphoric acid molecule is replaced with an ammonium ion, MAP is more stable than DAP, nitrogen slip during production is lowered, and scrubbing problems are decreased.

MAP should become the phosphate source of the future. MAP not only makes good fluids but is a better material for bulk blending than DAP. MAP is more stable than DAP, has a lower $N:P_2O_5$ ratio (11-53-0 rather than 18-46-0), and has less tendency to cause germination damage when placed close to the seed. It usually produces blends with lower critical relative humidities than DAP.

Some ammonium phosphate companies are converting from the traditional preneutralizer to the TVA pipe-cross reactor (PCR) to produce MAP. At least one company is experimenting with use of the PCR to produce DAP. Although MAP is easily produced with this device, some problems remain with DAP production because of nitrogen slip caused by the high temperatures involved. The PCR, however, is much simpler to operate and easier to start up and shut down than a preneutralizer. I believe that with revisions in the scrubbing system used in traditional DAP plants, DAP can be produced with the PCR.

At least one company is using the PCR to produce granular ammonium polyphosphate (GAPP) which is targeted for fluid fertilizers. This GAPP will contain 15 to 20% of the P_2O_5 as polyphosphate. The polyphosphates will sequester impurities in fluids keeping them from precipitating. This improves the quality of the fluid fertilizers made from GAPP. I expect most companies now producing MAP for the fluid fertilizer industry to change to granulation by the PCR and to make not only MAP but GAPP.

Fluid Fertilizers

Fluids, especially suspensions, are competitive with dry blends. MAP used as a phosphate source is competitive with DAP. Fluid grade potash (62% K_2O) is priced at the same price F.O.B. as coarse (60% K_2O) potash and is cheaper than granular potash (3). What many fluid producers are just learning is that they now have a low-cost nitrogen source which can keep them competitive or may even give them a slight advantage over dry blends. Fluid manufacturers already know that the ammonia they are using is their lowest cost nitrogen source. However, they are just beginning to realize that they too can use low-cost urea as a supplementary nitrogen source if they understand the techniques involved.

Urea ammonium nitrate (UAN) solution can be produced from solid urea and either solid ammonium nitrate or ammonium nitrate liquor at fluid plants. Both solid urea and ammonium nitrate have negative heats of solution, and usually some external heat must be added to the process for a satisfactory production rate. External heat is usually not required, however, if hot ammonium nitrate liquor is used.

Many fluid fertilizer producers are considering such a process and may begin to produce their own UAN solution. Low-cost imported urea will probably begin or may have already begun to be used in conventional UAN solution plants too.

In a few suspension plants, ammonia is being substituted for UAN solution. Most fluid manufacturers know that the maximum solubility point of ammonium phosphate or ammonium polyphosphate mixtures is at about the 1 to 3.4 nitrogen to P_2O_5 ratio (for example 10-34-0). They also know that adding more ammonia to such a mixture precipitates DAP and if even more ammonia is added that there is ammonia loss. Suspensions can be made, however, with all nitrogen from ammonia if they are handled in closed systems. Mixing, storage, and application techniques are available for making these suspensions. The suspensions have vapor pressures up to 6 pounds-per-square-inch gage; however, if they are handled in closed systems like aqua ammonia or low-pressure nitrogen solution and knifed into the ground when applied, they can be used. Cost savings obtained from getting all of the nitrogen from ammonia may make the extra trouble worthwhile.

At the other end of the pH chart, fertilizers can be produced directly from phosphoric acid or sulfuric acid merely by adding urea and potash. Most of these systems, including one developed by TVA, are covered by patents. The TVA patent involves the adding of ammonium nitrate as well as urea to the phosphoric acid.

Wet-process orthophosphoric acid also can be used to produce polyphosphate. Without adding any external heat to the system, a TVA ammonium polyphosphate plant will produce a 9-32-0 suspension with about 20% of the P_2O_5 as polyphosphate. This process uses the heat of reaction of ammonia and acid to vaporize the ammonia and heat the incoming phosphoric acid. One company uses the TVA process to make an 8-26-0 solution. The polyphosphate produced sequesters the impurities in the acid and produces a clear solution. The TVA process is attractive if orthophosphoric acid can be delivered cheaper than superphosphoric acid. If sulfuric acid is added to the reactor, an 11-33-0-3S suspension with 50% of the P_2O_5 as polyphosphate can be made. Lower analysis solutions containing sulfur can also be made.

In certain areas high magnesium superphosphoric acid is competitive with orthophosphoric acid. High magnesium superphosphoric acid can be put through a TVA pipe reactor to produce a high polyphosphate (60+% of the P_2O_5 as polyphosphate) product. The magnesium will precipitate from this product, but clay is usually added to keep it in suspension. Some producers are allowing the magnesium to settle. After settling, clear liquid is taken from the top of the storage tank to make starter fertilizers, and sludge from the bottom to make suspensions.

Fluid manufacturers, like dry bulk blenders, are beginning to tap the high profit lawn and garden market. Most use electric furnace orthophosphoric acid or superphosphoric acid. They neutralize the acid with potassium hydroxide and add urea and potash. Other manufacturers try to use as much ammonia as possible with the electric furnace acid. Some try to produce slow-release liquids by adding water-soluble methylol urea to their fertilizer. Others suspend urea formaldehyde solids. The solids are usually bought from a urea formaldehyde producer but sometimes are made in the plant from partially finished urea formaldehyde liquids which can be bought from nitrogen producers.

Industrial Wastes Containing Plant Food

One of the most active areas in the fertilizer industry is use of waste products containing plant food as fertilizer. Many of these products have been discarded into hazardous waste dumps or settling ponds. These methods are becoming both expensive and risky. Most wastes are low analysis which makes them uneconomical to use as fertilizer. Some contain impurities which interfere with their use as plant food. In many cases the effect of the impurities on soil and crops has not been evaluated. These wastes can usually be used as fertilizer if they receive proper treatment.

An example of a byproduct being used as fertilizer is pickling acid from galvanizing plants. This acid is combined with urea or urea and ammonia and used as fertilizer. Granular ammonium sulfate can be made from spent sulfuric acid and fluid fertilizer from spent bright-dip phosphoric acid. Some sewage sludge can be applied directly to the soil. Other possibilities are cement, sulfuric acid and sulfur from gypsum, and ammonium polysulfide from natural gas-cleaning processes.

Computer Programs

Computers are just beginning to be used in the fertilizer industry. TVA has a program which calculates formulas for bulk blend, fluid, and granulation plants. TVA is also working on a program for ammonium phosphate plants which will evaluate independent variables such as a P_2O_5 in phosphoric acid, phosphoric acid temperature, and reactor N:P mole ratio. The program will adjust for the effect of these variables on dependent variables such as percent polyphosphate in the product and ammonia slip. Eventually ammonium phosphate plants probably will be designed and operated using such programs.

Pollution Problems

Increases in nitrates in groundwater are causing environmental agencies to take a closer look at runoff from fluid and bulk blend fertilizer plants. Many fluid plants have been closely watched for some time but most bulk blenders are just now beginning to deal with runoff problems. Collection of runoff water in ponds and buried tanks has been a common way to contain runoff from fluid plants. EPA regulations on containment ponds and underground storage tanks are becoming more stringent, and the cost of maintainin these ponds and tanks may become prohibitive for the average fluid fer ilizer or bulk blending plant. A partial answer seems to be to rinse application equipment in the field and apply the rinse water to the farmer's field. This solves both the collection problem caused by rinsing equipment at the plant and puts the rinse water to good use. Of course, as with most solutions to tough problems this is more complicated than it sounds.

Application

The spinner-spreader truck has been the most popular device for spreading fertilizer for the past 35 years. No other applicator is as economical to buy and as easy to maintain, and cover as many acres as rapidly as the spinner-spreader. The simplicity and speed of these machines has contributed to their popularity despite their tendency to cause streaking in fields from nonuniform application. In the past 5 years, however, equipment manufacturers have developed machines that are advertised as being able to broadcast dry fertilizer with greater accuracy and uniformity. These spreaders are commonly referred to as "boomed dry spreaders" and are either pneumatic or auger type. These machines are more expensive to buy than spinner spreaders but TVA tests show that they do produce a more uniform pattern without the spread pattern testing and adjustment required for spinner applicators.

Broadcast application has often been inferior to surface and subsurface banding, particularly under reduced tillage. Equipment manufacturers, both dry and fluid, have responded to agronomic studies by developing applicators specifically designed for banding fertilizer. Though broadcast application is still a common practice on minimum tilled land, the trend is toward precision placement or banding.

Electronic rate monitors and controllers are being sold by several manufacturers. Although development of these devices has not been entirely in response to minimum till farming, their use on minimum tilled applicators is growing. The devices include speed sensors, rate sensors, and flow controllers. Speed sensors can be the radar-type or can be magnetic or mechanical. Radar speed sensors are very accurate but are still expensive. The cost of these devices is expected to continue to drop.

Farmers and equipment manufacturers should continue to respond to agronomic research that supports precision fertilizer placement. Benefits from precision placement often outweigh the extra time and energy required compared to broadcast application. Use of urea-containing fertilizers may require precision placement as farmers seek to avoid nitrogen losses from volatilization.

Conclusion

The fertilizer industry is maturing but this does not mean that it is not changing. Today's changes are more subtle. Even the smallest fertilizer plants are beginning to encounter some of the problems faced only by the largest companies a few years ago. Two examples are pollution control and quality control.

New raw materials, which require more knowledge and more sophisticated equipment but which lower the cost of fertilizer to the farmer and improve agronomic efficiency, are becoming common. Imported raw materials, which are lower in cost but which can create quality control problems, are available. The dealer must learn how to use them.

Wastes from other industries which contain low-cost plant food are becoming available. But some contain a bewildering array of impurities. These impurities must be evaluated before they are applied with the fertilizer. Regulations complicate the use of even the purest of these byproducts even when the logical way to dispose of them is to use them as plant nutrients. Often the alternative is to put the waste into deep wells where they may contaminate the groundwater or try to contain them in ponds or to bury them and hope that they remain in place forever.

Computers are becoming more common and will be used not only to keep account and calculate formulas but to operate plants and evaluate the effects of raw material variables on plant operation. They also will be used to design plants which will adjust to changes in raw material analysis.

Application equipment is becoming more efficient through the use of ground and rate measuring devices and boomed dry spreaders. But the equipment is more expensive. It will take a wise manager to obtain maximum return on his investment with this equipment.

The fertilizer business is changing and will continue to change. Research will become more complex but will be even more necessary. Good management will continue to take advantage of these changes. In short, the fertilizer business will be different, but it will be better.

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References

1. AAPFCO-TVA Fertilizer Plant Surveys, 1984 and 1985.

2. Green Markets Price-Scan, Green Markets, December 23, 1985, p. 6.

3. Hoffmeister, George. "Compatibility of Raw Materials in Blended Fertilizers-Segregation of Raw Materials," Proceedings of the 12th Annual Meeting of the Fertilizer Industry Round Table, Washington, D. C., 1962, pp. 80-83.

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Table 1

Distribution of Fertilizers
% of Total Fertilizers[a]

Class	U.S. 1976	U.S. 1979	U.S. 1984	N.Y. 1976	N.Y. 1979	N.Y. 1984
Dry bulk blends	34	36	39	13	NA[b]	38
Dry bagged blends	6	6	5.5	5	NA	19
Subtotal	40	42	44.5			
Bulk granulation	10	10	8	22	NA	2
Bagged granulation	9	6	2.5	43	NA	5
Subtotal	19	16	10.5			
Fluid mixtures (Liquid & Susp)	10	10	11	3	NA	17
Anhydrous ammonia Nitrogen solutions Direct application Materials	31	32	34	14	NA	19

a. AAPFCO-TVA Fertilizer Plant Surveys
b. 1979 data for New York not available

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