DAP vs. MAP - MANUFACTURING/MARKETING IMPLICATIONS

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Over the past several years, discussions on the suitability of monoammonium phosphate (MAP) and diammonium phosphate (DAP) as P sources for crop production have been common. In addition to agronomic principles, these discussions have often focused on what the future holds on the availability of these two materials in the marketplace. This discussion will deal with manufacturing and marketing influences on future availability/use, while agronomic comparisons will be made elsewhere.

To some, phosphate fertilizer production seems fairly straight forward. Simply react phosphate rock (calcined, if necessary) with sulfuric acid, remove gypsum to obtain phosphoric acid, ammoniate the acid to make ammonium phosphates (or react this phosphoric acid with phosphate rock to make triple super-phosphate) and transport these products to retail outlets. It might seem that all that has to be done is figure out which product(s) will make the most money in various markets, decide on the amounts of each product to make, then make them. Unfortunately, it is not this simple.

The phosphate production/marketing/distribution system is very complex, with the final product mix in a market being the result of a balancing act which includes; phosphate rock quality, impurity management, export demand, domestic demand, tightly held traditions, consumer perceptions, technological improvements, distribution realities and other interrelated factors.

While this discussion will touch on some of the manufacturing and marketing considerations that influence the phosphate industry, keep in mind that it will be somewhat general in nature since manufacturing and marketing challenges are different for producers in Florida, North Carolina and the West. In addition to phosphate rock differences for various producers, there are differences in specific production process employed and the relative influence of the export/domestic markets. Also, since the author is an agronomist, many of the intricacies of phosphate manufacturing may not be covered in the same manner as would be by an engineer.

Presented at the nineteenth North Central Extension-Industry Soil Fertility Workshop, November 8-9, 1989, St. Louis, MO.

PHOSPHATE CONSUMPTION, PRODUCTION, EXPORT OVERVIEW

In the not to distant past, DAP and triple superphosphate (TSP) dominated U.S. phosphate production. During the mid-late 1980's, however, U.S. MAP production and consumption surpassed TSP on a P_2O_5 basis. During this same time frame, ammonium polyphosphate solution (APP, 10-34-0) consumption also surpassed TSP consumption on a P_2O_5 basis (Fig. 1,2). Since 1981, DAP production has been variable, but trending up - while DAP consumption has been variable but generally flat. Triple superphosphate (TSP) production and consumption have steadily declined during the 1980's. MAP consumption/production and liquid ammonium polyphosphate consumption (APP, 10-34-0) have registered consistent gains in this decade. As will be discussed later, these shifting P_2O_5 trends relate to why we might expect the U.S. fertilizer industry to continue strengthening it's efforts to increase domestic MAP consumption in the future.

With this increased emphasis of MAP in some regions of the country, the question might be raised, "Is MAP likely to replace DAP as the dominant dry phosphate fertilizer?". No, at least not in the foreseeable future - and for several reasons. First, DAP (18-46-0) is the dominant P_2O_5 source in the world - the world yardstick against which all other phosphates are measured by, and by which prices are set. In recent years, about 55% of the U.S. P_2O_5 supply has been exported (P_2O_5 supply defined as the sum of production plus exports), and about 55-60% of U.S. P_2O_5 exports have been as DAP. The relative importance of MAP in export sales is small compared to DAP but has trended up - from 4.0% of P_2O_5 exports in 1982 to 8.2% in 1988 (compared to 58.2% for DAP in 1988). Merchant grade phosphoric acid exports have averaged about 24% of total P_2O_5 exports since 1981 (Fig. 3).

In addition to dominating world P_2O_5 trade, DAP has a well established world marketing structure, and a totally different international mind-set would be required before MAP could replace DAP in international importance. In essence, tradition plays a key role in determining which products are likely to be of world importance in the future.

REASONS FOR INCREASED PROMOTION OF MAP GRADES

Declining Phosphate Rock Quality.

Over the years, we have sometimes heard comments implying that the U.S. phosphate rock reserves were rapidly dwindling and that we will shortly "run out" of phosphate rock. This is not true - we still have vast U.S. phosphate deposits. What has happened, however, is that since the early 1970's the quality of the phosphate rock being mined has declined. During this time period, impurity levels of the phosphate rock have increased and the phosphate content has declined.

In years past, phosphate rock utilized by Florida producers had a bone phosphate of lime (BPL) content of 72-76% (32.9-34.8% P2O5). Currently, Florida phosphate rock is typically 65-68% BPL (29.7-31.1% P2O5). At the same time, impurities levels (Ca, Mg, Fe, Al, etc.) have increased. These same impurities report to the phosphoric acid used to produce phosphate fertilizers.

As a result, many producers are having greater difficulty in making on-grade DAP. Specifically, there are difficulties in fully ammoniating the phosphoric acid to a N:P2O5 ratio of 0.391 as is required for an 18-46-0 grade of DAP. Fully ammoniated DAP (two moles of ammonia per mole of phosphoric acid) has a N:P2O5 ratio of 0.394, therefore, 18-46-0 DAP is 99% ammoniated. With increasing metal cation impurities present in phosphoric acid, some of the phosphoric acid is already combined with these metal impurities - as a result, there isn't "enough room" for the required ammonia. Ammoniation to a MAP grade is much easier since it contains a much lower N:P2O5 ratio.

Because of tradition, the international and domestic markets recognize only one DAP grade - 18% N and 46% P2O5. As a result, DAP is often (not always) spiked with urea and/or nitric acid to increase the N content to the required 18 percent. If common sense - not tradition - would take precedence, producers could make a slightly lower DAP grade (e.g. 17.5-45.5-0) and there might be somewhat less pressure on the industry on increasing domestic MAP consumption. It must be pointed out, and will be covered later, that there may be other reasons producers would prefer to make at least some MAP.

The trend of increasing levels of impurities in phosphate rock will likely continue in the future. As a result, it may become more and more difficult for some producers to make on-grade 18-46-0 DAP. Also, there may be a greater sludge acid supply (discussed later) to deal with in the future. However, improvements in processing technology now allows producers to successfully deal with impurity levels that would have caused major production problems in the past. Continued development and refinement of more effective processing technology is likely to offset many future problems associated with declining phosphate rock quality.

Increased Sludge Acid Supply/Declining TSP Production.

Sludge acid contains about 38-42% available P2O5 and about 20% solids. Variable amounts of the P2O5 are present as complex metal phosphates as well as varying percentages of citrate soluble/water insoluble P2O5. There are two main sources of sludge acid - the production of wet process superphosphoric acid (0-68-0, less than 0.5% solids) and merchant grade phosphoric acid (50-52% P2O5) containing about 1.5-2% solids (Fig. 4).

Since 1980, 10-34-0 consumption has increased from 231,000 tons of P2O5 to 304,000 tons in 1988 - with a high of 333,000 tons in 1985 (Fig. 2). Due to storage considerations, 10-34-0 must be made from superphosphoric acid (0-68-0) containing relatively low impurity levels (less than 0.5% solids). Typically, super acid is made by removing the solids by centrifuging phosphoric acid containing about 10% solids and then removing water in an evaporator. Generally, for each ton of 10-34-0 ultimately produced in the field, about 340 pounds of sludge acid result at the super acid production site. Stated another way, about 0.5 ton of sludge acid results for each ton of P2O5 as super acid produced.

Merchant grade phosphoric acid is made by removing most of the solids by centrifuging acid containing about 10% solids. Merchant grade phosphoric acid (1.5-2.0% solids) must contain relatively low levels of solids to prevent excessive sludge formation during transit (settling of solids). Exports of merchant grade phosphoric acid have averaged about 1.13 million tons of P2O5/year since 1981 (Fig. 3), accounting for slightly more than 24% of total P2O5 exports during this time period. Additionally, substantial tonnages of merchant grade acid are used domestically.

Since sludge acid cannot be utilized in the production of on-grade DAP, it has historically been used in TSP production. As the amount of impurities increased in the phosphoric acid over the past years, more sludge acid was included in TSP production and we saw the guaranteed analysis of TSP slip from 0-46-0 to 0-45-0 and sometimes to 0-44-0, while the water soluble fraction of available P2O5 slipped as well.

TSP production has several disadvantages as compared to MAP or DAP, including lower daily P2O5 production rates (about 50% of MAP P2O5 rate if plant has both TSP and MAP capabilities), the requirement of very finely ground, high grade phosphate rock and higher production and distribution costs. Also, TSP typically has a greater tendency to cake in storage than does DAP or MAP. Consequently, many producers no longer produce TSP, as is evidenced by the nearly 50% decline in TSP production during the 1980-88 time period (525,000 tons P2O5 to 268,000 tons).

With the decline in TSP production, various MAP grades are currently used to "dispose" of sludge acid. Generally, 11-52-0 MAP production incorporates very little sludge acid, while 10-50-0 MAP contains relatively greater amounts of sludge acid (Fig. 4). As a result, 11-52-0 MAP will contain about the same percentage of water soluble P2O5 (% of available) as DAP, while lower analysis MAP grades may contain slightly lower percentages of available P2O5 in a water soluble form. Sludge acid is also used to produce a variety of N-P-K products.

"Acceptable" Grades In Marketplace.

The fact that there is no one "acceptable" grade for MAP as there is for DAP provides flexibility in the production process. Common MAP grades over the past few years have included, 11-54-0, 11-53-0, 11-52-0, 11-51-0 and 10-50-0. Plant efficiency can be improved by producing MAP grades suited to sludge acid production. However, there appears to be some arbitrary reluctance on the part of certain international market segments to accept phosphates containing significant amounts of the available P2O5 in a water insoluble/citrate soluble form. This precludes the exporting of some MAP and TSP products to these markets, resulting in greater pressure to incorporate these products in domestic markets. Past agronomic research has indicated no difference in performance due to water soluble P2O5 percentages in the 70-100% range.

P2O5 Production Rates.

In general, operating rates are higher for MAP production than DAP production. While these percentages may vary depending on the specific process and plant design utilized, the P2O5 production rate for DAP may be only two-thirds of what can be produced as MAP. This obviously would improve plant efficiency.

Ammonia Handling.

In addition to the fact that ammoniation to MAP is easier than for DAP (as discussed earlier), the fact that MAP contains less ammonia per pound of P2O5 than DAP is also important. Ammonia is not produced near the Florida phosphate complexes, it must be brought in by pipeline, rail or trucks. The ammonia used is usually produced in Louisiana or imported from foreign producers. After transporting ammonia to the phosphate production sites, it is then "exported" back out as ammonium phosphates. It is desirable to handle as little ammonia as possible - since these producers are in the business of selling phosphates not nitrogen - and 11-52-0 MAP contains 46% less ammonia per pound of P2O5 as does 18-46-0 DAP.

Storage/Warehousing Considerations.

Each ton of 11-52-0 MAP contains 13% more P2O5 than DAP. Basically, more P2O5 can be stored at a storage facility as MAP than as DAP. This is important at the production site (since storage capacity relative to daily production rates is limited) and at warehouses and retail locations. Similarly, for each ton of P2O5 shipped as DAP, 13% less tonnage would be required for the same amount of P2O5 as 11-52-0 MAP.

Easier On Production Equipment/Product Quality.

Some producers report less downtime (equipment problems) for MAP production as compared to DAP. This would result in higher plant operating efficiencies and decreased capital related costs (per unit of production). Also, some producers have experienced fewer storage problems (caking) with MAP than for DAP. Others, however, feel that there may be greater amounts of "fines" associated with MAP as compared to DAP.

SUMMARY

The entire phosphate industry is very complex, and the manner in which it operates depends on many interrelated factors. Phosphate rock composition, impurity management, export and domestic demand, traditions, perceptions, technological refinements, international politics, agronomics, and other factors all influence the composition and supply of phosphate products. While DAP is likely to continue as the dominant dry P_2O_5 material in the U.S. and world, many of these factors have led many phosphate producers to increase their promotional efforts for various MAP grades.

* Changes in phosphate rock composition has resulted in higher metal impurities in phosphoric acid and increased difficulty in making on-grade 18-46-0 DAP. In general, it is harder for many producers to make grade on N than in the past..

* For various reasons, TSP production has declined markedly over the past 10 years, while the demand for liquid 10-34-0 has increased. Combined with the changes in phosphate rock quality, there is increasing pressure to incorporate greater amounts of sludge acid (which largely went into TSP in the past) in other phosphate products. Since on-grade DAP cannot utilize this sludge acid, various MAP grades are good candidates for utilizing this sludge acid since there is no single "acceptable" MAP grade.

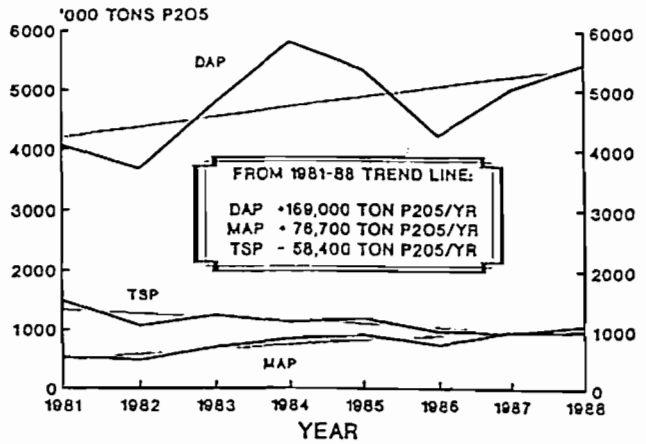
* For a given investment, P_2O_5 production rates (tons/day) are higher for MAP than for DAP. Additionally, many producers experience less downtime (fewer equipment problems) for MAP production as compared to DAP.

* MAP contains more P_2O_5 and less N than DAP. A ton of MAP (11-52-0) contains 46% less N and 13% more P_2O_5 than a ton of 18-46-0 DAP. Producers are in phosphate business, not N.

It is in everyone's best interest - farmers, agribusiness and producers - to accept a mix of MAP and DAP in the marketplace. Allowing producers to vary the mix of these products will allow for efficient plant operation and impurity management, as well as meet export demands. In turn, P_2O_5 production costs can be minimized, helping to insure a competitive American agriculture.

FIG. 1. P2O5 PRODUCTION - USA

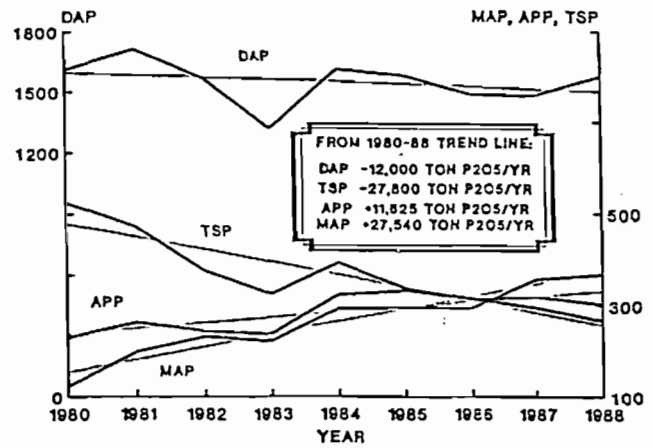
'000 TONS P2O5



ADAPTED FROM VARIOUS TVA-NFDC SOURCES

FIG. 2 U.S P FERTILIZER CONSUMPTION

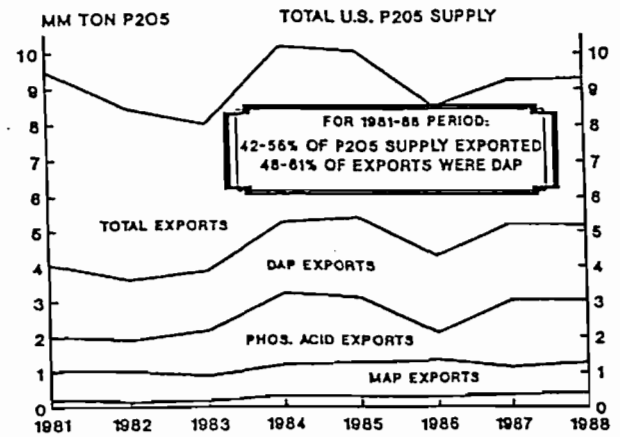
'000 TONS P2O5



ADAPTED FROM VARIOUS TVA-NFDC SOURCES

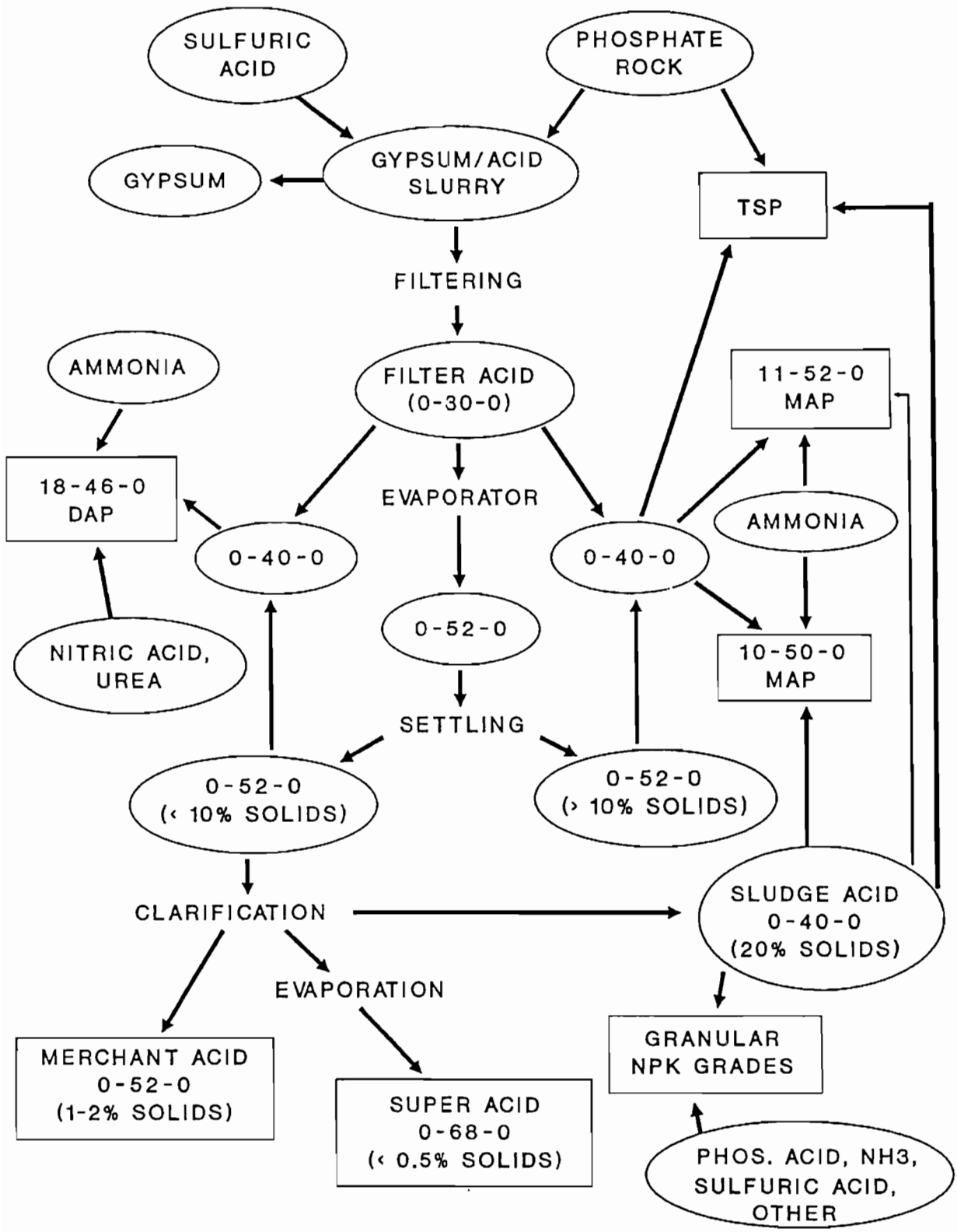
FIG. 3. U.S. PHOSPHATE EXPORTS

MM TONS P2O5



ADAPTED FROM VARIOUS TVA-NFDC SOURCES

FIG. 4. PHOSPHATE PRODUCTION FLOWCHART



PROCEEDINGS OF THE NINETEENTH

NORTH CENTRAL EXTENSION - INDUSTRY SOIL FERTILITY CONFERENCE

November 8-9, 1989, Holiday Inn St. Louis Airport

Bridgeton, Missouri

Volume 5

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