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ECONOMICS OF MARKETING AND DISTRIBUTION OF SUSPENSION FERTILISERS IN THE UNITED STATES

by

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Recent developments in process technology and equipment design have overcome many of the problems previously associated with suspension fertilizers. The recent rapid growth of suspension fertilisers in the U.S. is evidence of their effective fulfillment of a long-term industry need for a quality fluid fertilizer at the cost advantages of traditional dry blend products.

SUSPENSIONS DEFINED

Suspensions are defined as fluid mixtures of liquids and well-dispersed, finely divided solids stabilized by appropriate gelling agents. Suspension fertilizers therefore have some of the physical characteristics of both dry solids and clear solutions. Processing technology and equipment design must reflect these peculiar characteristics of suspensions.

The impurities in commercial fertilizer products are insoluble solids. Suspension techniques and equipment can accomodate these solids. Therefore, common unrefined raw materials containing solid impurities can be used in making suspension fertilizers. Since the suspension system is handling solids dispersed and dissolved in liquids, solubility levels can be exceeded and salt-out conditions are less critical than with liquid solutions.

These characteristics permit use of a variety of low cost, unrefined, common solid and liquid fertilizer raw materials in a suspension program. The chemical and physical properties of fertilizers suspensions are extremely complex, yet these can be reduced by knowledgeable technicians to easy techniques of plant design, process and handling. Failure to recognize the unique properties of fertilizer suspensions and methods for proper handling and processing can lead to disaster. It is recommended that distributors considering modern suspension programs obtain qualified technical counsel.

SUSPENSION MATERIALS

Suspension fertilizer systems permit the distributor to select from a wide range of raw materials, micronutrients, and minor element sources. His objective should be to selectthose materials which are reasonable in cost, which permit low cost handling and processing at efficient production rates and produce stable, easily handled, quality products. The capability to formulate to specific agronomic requirements for type and condition of soil, climate, and crop yield objective is an essential advantage of fluid fertilizers. Materials should be selected to support a merchandising program encompassing these advantages.

The dealer should make his material selection on the basis of which materials will serve him most profitably. Often the lowest cost material will carry impurities which contribute to inefficient processing and handling and will impair product quality.

Alternatively, highly refined raw materials may provide handling efficiencies and good product quality but at costs which cannot be profitably recovered in a competitive market. In selecting raw materials for a suspension fertilizer program, the effect on product quality and on processing must be weighed against the costs of optional materials.

PHOSPHATE MATERIALS

Typical fertilizer suspension processes generally rely on the reaction of various acid phosphate materials with anhydrous ammonia to solubilize the phosphates. High shear mixing equipment is required for efficient reaction and dispersion of undissolved solids and to form the suspension gel. The quantity of anhydrous ammonia used to react with and solubolize the phosphate is limited by the amount of acidic phosphate in the raw material source. For example, with phosphoric acid, all of the phosphate is acidic and available for reaction. With ammonium phosphate materials, such as 11-54-0 MAP, some of the acidic phosphate is already reacted with ammonia limiting the amount of additional ammonia which can be reacted. In the case of 18-46-0 DAP, the phosphate is completely reacted and no additional ammonia reaction can occur.

Selection of the phosphate material is primarily determined by its relative cost. However, the cost of special storage, transportation and handling equipment and process considerations should be evaluated. Since 18-46-0 DAP is the primary ammonium phosphate material used in the U.S. for dry-blending and direct application, the phosphate materials used in suspensions should be selected on the basis of cost parity with 18-46-0.

The following series of equations may be used to develop the delivered cost of phosphate materials that provide suspension products at costs competitive with dry blends.

Figure I

DAP EQUIVALENT COST OF SUSPENSION PHOSPHATE MATERIALS

Phosphoric Acid	0-54-0	$C = 1.1738 \times \overline{DAP} - 0.2567\ NH3 - \$\ 5.03$
Solution	10-34-0	$C = 0.7392 \times \overline{DAP} - 0.0355\ NH3 - \$\ 3.94$
Solution	11-37-0	$C = 0.8043 \times \overline{DAP} - 0.0422\ NH3 - \$\ 3.46$
	13-38-0	$C = 0.8260 \times \overline{DAP} - 0.0226\ NH3 - \$\ 3.00$
MAP	10-50-0	$C = 1.087 \times \overline{DAP} - 0.1165\ NH3 - \$\ 4.62$
	11-52-0	$C = 1.1305 \times \overline{DAP} - 0.114\ NH3 - \$\ 4.81$
	13-52-0	$C = 1.1305 \times \overline{DAP} - 0.0895\ NH3 - \$\ 4.77$
	11-54-0	$C = 1.1738 \times \overline{DAP} - 0.123\ NH3 - \$\ 5.02$
	11-55-0	$C = 1.1960 \times \overline{DAP} - 0.128\ NH3 - \$\ 5.11$

C = Delivered cost per ton of phosphate product
$\overline{DAP}$ = Delivered cost per ton of 18-46-0 DAP
$\overline{NH3}$ = Delivered cost per ton of anhydrous ammonia

NOTE : The above equations were derived assuming a differential of \$ 0.08 per pound for N from UAN solution over the cost of N from anhydrous ammonia.

If we use the distributor prices for DAP and ammonia reported in Green Markets for the Midwest in the spring of 1978, we can substitute these values into the equations as shown to determine parity values with DAP :

Example 1 - Parity Value of Phosphoric Acid (0-54-0)

C = 1.1738 x DAP - 0.2567 x NH3 - $ 5.03
= 1.1738 x $ 148- 0.2567 x $ 115 - $ 5.03
= $ 139.17/ton Delivered ($ 2.58/unit)

Example 2 - Parity Value of Solution (11-37-0)

C = 0,8043 x DAP - 0.0422 x NH3 - $ 3.46
= 0.8043 x $ 148 - 0.0422 x $ 115 - $ 3.46
= $ 110.72/ton Delivered.

Example 3 - Parity Value of MAP (11-54-0)

C = 1.1738 x DAP - 0.123 x NH3 - $ 5.02
= 1.1738 x $ 148 - 0.123 x $ 115 - $ 5.02
= $ 154.56/ton Delivered

NITROGEN MATERIALS

A product ratio of 1.0 N to 3.0 P_2O_5 is typical from the reaction of ammonia with the acid phosphate. If additional nitrogen is needed to balance out a formulation, it can be obtained most easily from UAN solution. However, ammonium sulfate (fine grade), urea or ammonium nitrate may be used. Practical plant design should provide hoppers or other dry material feed systems to permit use of a variety of raw materials. This permits the dealer to take advantage of raw material price changes and provides for full flexibility in meeting nutrient and minor element requirements.

Dry nitrogen materials such as urea, ammonium nitrate and sulfate of ammonia when used alone are less soluble than the UAN combination of urea and ammonium nitrate. Additional water may be required when using these materials resulting in some reduction of the final product analyses due to dilution. Prilled or granular urea may be used in most grades up to about 500 pounds per ton without grinding. Because of the low solubility of ammonium sulfate,the fine grade should be used unless grinding is possible.

POTASH MATERIALS

The standard grades of muriate of potash may be used for suspensions. Coarse potash grades are not desirable since they must be ground fine to be effectively used in fertilizer suspensions. The extra fine grades of muriate known as superfine or uniscreen, the water soluble grades or the special suspension grades of muriate of potash are preferred. Regular standard grades may be used for broadcast application with size 80 nozzles or greater. High potash grades at low application rates are best handled when made from fine grades of standard muriate of potash.

MINOR ELEMENTS AND OTHER MATERIALS

The chelated or complexed solution forms of micronutrient materials commonly used in clear liquid fertilizers can be easily used in fertilizer suspensions. It is not necessary to use solubolized micronutrient sources. However, fine grades of sulfate of potash or sulfate of potash magnesia may be used in suspension formulations to meet potassium, sulfur and magnesium requirements. These materials are dense and abrasive and require special handling and process techniques to insure quality suspension products.

With the exception of elemental sulfurs and sodium borate, common metalic-salt sources of micronutrients and minor elements may be reactive with ammonia, water and/or ammonium phosphates. The reaction products are insoluble in water and if improper techniques are used excessive thickening of the suspension fluid can result and salted out crystals can settle to form hard cakes. Generally, the sulfate forms of metal salts are less reactive than the oxide forms. Reactivity of these metal salts will also vary with suppliers and may vary between shipments from the same supplier. Because of the complex chemistry involved in the metal reactions in the suspension fertilizer medium, it is recommended that expert technical advice be obtained by the dealer before attempting use of metal salts as plant nutrient sources.

GELLING AGENTS

Gelling agents most commonly used are attapulgite clays. These are finely ground clays with needle-like crystals which when sheared and hydrolized have a unique capacity to form a liquid gel. The gel holds the undissolved materials in suspension. Important to the stability of the suspension fertilizer is the type of clay, the degree of clay shear, the gel characteristics, the solids content of the fluid, the raw materials impurities, the temperature of the product, the efficiency of ammoniation reaction, and the effective dispersion and solution of solid materials. Attapulgite clays are most commonly used because they easily form effective gels in electrolytic fertilizer solutions. Sepiolite clays have properties similar to a attapulgite clays and also perform well in fertilizer suspensions.

SUSPENSION FERTILIZER ADVANTAGES AND ECONOMICS

Agrico's entry into the fluid mixed fertilizer market in 1975 was through its innovative Fluid Blend suspension process * based upon monoammonium phosphate (MAP), as the phosphate raw material. Since then, we have worked with over one hundred distributor installations on Fluid Blend suspension programs. Through this experience we have become knowledgeable of the particular distribution economics of the MAP-based Fluid Blend system. The thrust of this discussion will be to the economics of the system we know best from first-hand experience.

* U.S. Patent n° 4081266

SUSPENSIONS BENEFIT MANUFACTURER, DISTRIBUTOR, AND FARMER

Agrico selected granular MAP as the phosphate base material for its suspension mixed fertilizer program because it fitted our manufacturing and distribution system and provided economic benefits to manufacturer, distributor, and farmer.

Manufacturer Advantages

Advantages to Agrico as a manufacturer derive from our phosphate processing plant design, which allows production of MAP or DAP in the same ammoniation-granulation trains. This flexibility permitted entry as a supplier to the fluid mixed fertilizer market without additional plant investment. The existing P_2O_5 ammoniation trains producing DAP were utilized for MAP production simply by changing the formula and controlling the plant sludge balance. Production rate in product tons per hour of MAP is the same as the DAP production rate. In terms of P_2O_5, there is a potential of a 17 % increase in up-grading capacity over DAP by producing a 54 % P_2O_5 product at the same production rate as the 46 % P_2O_5 DAP product. The granular MAP product does not require specialized transportation, storage and handling equipment and, therefore, provides transportation and distribution savings over phosphoric acid and other fluid phosphates.

Additional advantages can result from the potential of granular MAP as a universal phosphate base material for use in direct application, as a base for dry blends and suspensions, and as a base for chemically mixed granular fertilizers. This adaptability of MAP to various applications enhances potential transportation, storage, distribution savings. The low nitrogen and high phosphate content of MAP make it a promising material as an intermediate for the world market.

Distributor Advantages

The MAP-based Fluid Blend program offers economic and merchandising advantages to the distributor. This suspension system provides the superior handling and application advantages of fluid mixed fertilizers at costs competitive with traditional dry blends. With correct process technology and proper design of plant and equipment, homogeneous suspension mixtures of primary, secondary, and micronutrients are easily produced and applied. Frequently chemicals for insect and weed control can be added to save application time and cost. Problems of nutrient segregation typical of dry fertilizer mixes are eliminated and application is uniform. Distributors handling dry and fluid fertilizers can reduce inventory and handling costs by using granular MAP in both dry and liquid programs. Use of lower cost raw materials plus the processing and handling efficiencies of fluids offer greater profit margins at competitive retail pricing, as will be demonstrated later.

Farmer Advantages

A homogeneous mixture of plant nutrients and chemicals, that can be accurately and uniformly applied, has a strong appeal to the farmer. This system is furnished thru the MAP-based Fluid Blend program which makes it easy for the farmer to use the best agronomic technology in his fertilization programs. Using soil analysis, and crop history, he can apply prescription formulations specifically designed to meet his soil and climate conditions and to support his crop yield objectives. If he desires, his total nutrient and chemical program can be applied in one pass over the fields saving time and expense, and avoiding soil compaction from multiple passes. Custom application by the distributor can provide professional application services saving the farmer time and equipment investment. He has the option of applying the suspension fertilizer himself for starter applications.

Manufacturer Economics

The parity relationship of phosphates discussed earlier is a theoritical concept which overlooks supply-demand factors and other market variables which have impact on pricing. This concept can provide guidance to the manufacturer in determining likely long-term profitabilitv of the various product options in his particular manufacturing and distribution system.

Distributor Economics

The typical suspension fertilizer distributor following Agrico's Fluid Blend program finds he can compete well with his dry blend competition while obtaining higher gross margin on his sales. The flexibility and handling advantages of the fluid fertilizer program often permit retail pricing at a premium over the traditional dry blend programs. Gross margins on retail sales of Fluid Blend suspensions are typically about 30 %, compared to 22 %, which seems typical of dry blend gross margins.

Figures 2 through 5 develop material costs for four mixed fertilizer systems : clear solutions ; dry blend ; fluid blend ; and hot mix. Distributor delivered prices reported by Green Markets are used to develop product costs of a 5-15-25 grade.

These costs are summarized in Figure 6, which also develops retail pricing based upon the gross margins assumed. The Fluid Blend suspension product cost at $ 73.99 per ton is over $ 20 per ton cheaper than the polyphosphate solution system. The solution system offers advantages of simplicity in handling and processing as well as low plant and equipment investment, permitting lower gross margin requirements.

FIGURE 2

DISTRIBUTOR COSTS

CLEAR SOLUTION PROGRAM 5-15-25 (S-6-10 x 2.5)

	DELIVERED COST PER TON*	LBS/TON
H_2O		335
UAN 32-0-0	$ 88.00	34
POLYPHOS 11-37-0	162.00	811
SOLUBLE KCL 0-0-61	67.00	820
TOTAL	$ 94.66	2,000 LBS

* GREEN MARKETS - SPRING, 1978 - MIDWEST

FIGURE 3

DISTRIBUTOR COSTS

DRY BLEND PROGRAM 5-15-25

	DELIVERED COST PER TON *	LBS/TON
DAP 18-46-0	$ 148.00	556
GTSP 0-46-0	123.00	97
COARSE KCL 0-0-61	73.00	820
FILLER		527
TOTAL	$ 77.04	2,000

* GREEN MARKETS - SPRING, 1978 - MIDWEST

FIGURE 4

DISTRIBUTOR COSTS

FLUID BLEND PROGRAM	5-15-25 DELIVERED COST PER TON *	LBS/TON
10-30-0		
H_2O		536
MAP 11-54-0	$ 152.00	556
NH_3 82-0-0	115.00	48
STANDARD KCL 0-0-61	67.00	820
GELLING CLAY	75.00	40
TOTAL	$ 73.99	2,000 LBS

* GREEN MARKETS - SPRING, 1978 - MIDWEST

FIGURE 5

DISTRIBUTOR COSTS

HOT MIX PROGRAM	5-15-25 DELIVERED COST PER TON *	LBS/TON
10-30-0:		
H_2O		462
ORTHOPHOS. ACID 0-54-0	$ 130.00	556
NH_3 82-0-0	115.00	122
STANDARD KCL 0-0-61	67.00	820
GELLING CLAY	75.00	40
TOTAL	$ 72.13	2,000 LBS

* GREEN MARKETS - SPRING, 1978 - MIDWEST

FIGURE 6

SUMMARY - DISTRIBUTOR COSTS & RETAIL PRICING

5-15-25

	DEALER COST	GROSS MARGIN	RETAIL COST
CLEAR SOLUTION	$ 94.66/TON	15 %	$ 111.36
DRY BLEND	77.04/TON	22 %	98.77
FLUID BLEND	73.99/TON	30 %	105.70
HOT MIX	72.13/TON	31.8 %	105.70

Even with lower gross margin requirements, the higher material costs require a premium retail price for the clear solution programs. The polyphosphate content of clear solutions is often used as a basis for premium pricing, although many agronomic experts indicate polyphosphate has little agronomic value except in certain special soil conditions. The attached Appendix A summarizes the opinions of some agronomic experts regarding agronomic properties of polyphosphates.

The examples of Figure 6 indicate the Fluid Blend 5-15-25 to have slightly lower material costs than the dry blend product. This savings results from use of anhydrous ammonia and standard grades of potash. Fine standard potash is preferred, although regular standard potash can be used for broadcast application rates using size 80 nozzles or larger.

The hot-mix system using orthophosphoric acid develops the 5-15-25 product at the least material cost, saving $ 1.86 per ton over the Fluid Blend product. This lower material cost must be evaluated in terms of the additional capital investment and higher operating costs of the more-complex phosphoric acid conversion systems.

Farmer Economics

The comparative costs to the farmer of a dry blend program and Fluid Blend program are compared in Figures 7, 8, and 9. These examples compare three alternative programs for meeting a per-acre nutrient requirement of 150 Lbs. N, 75 Lbs P_2O_5, 125 Lbs P_2O_5. The retail pricing developed from the margins assumed in Figure 7 is used. A gross margin of 30 % is assumed for pricing of UAN solution, anhydrous ammonia, and urea. Distributor prices for these materials are those reported by Green Markets for spring 1978 Midwest delivery.

FIGURE 7

FARMER COSTS

PROGRAM A — ONCE-OVER PROGRAM 150-75-125

FLUID BLEND	
500 Lbs. 5-15-25 (a) $ 105.70	= 26.43
391 Lbs. 32-0-0 (a) $ 125,72	= 24.58
MIXING $ 4.00 x 891/2000	= 1.78
APPLICATION	= 2.50
CHEMICAL MIX & APPLICATION	= -0-
TOTAL/ACRE	$ 55.29
DRY BLEND	
500 Lbs. 5-15-25 (a) $ 98.77	= 24.69
272 Lbs. 46-0-0 (a) $178.58	= 24.29
MIXING $ 4,00 x 772/2000	= 1.54
APPLICATION	= 2.50
CHEMICAL MIX & APPLICATION	= 2.50
TOTAL/ACRE	$ 55.52

FIGURE 8
FARMER COSTS

PROGRAM B — SUPPLEMENT N FROM UAN 150-75-125

FLUID BLEND :

500 Lbs 5-15-25 @ $ 105.70	=	$ 26.43
MIXING $ 4 00 x 500/2000	=	1.00
APPLICATION	=	2.50
391 Lbs 32-0-0 @ $ 125.72	=	24.58
APPLICATION	=	2.50
CHEMICAL MIX & APPLICATION	=	- 0-
TOTAL / ACRE		$ 57.01

DRY BLEND :

500 Lbs 5-15-25 @ $ 98.77	=	$ 24.69
MIXING $ 4.00 x 500/2000	=	1.00
APPLICATION	=	2.50
391 Lbs 32-0-0 @ $ 125.76	=	24.58
APPLICATION	=	2.50
CHEMICAL MIX & APPLICATION	=	-0-
TOTAL/ACRE		$ 55.27

FIGURE 9
FARMER COSTS

PROGRAM C — SUPPLEMENT N FROM NH_3 150-75-125

FLUID BLEND

500 Lbs. 5-15-25 @ $ 105.70	=	$ 26.43
MIXING $ 4.00 x 500/200	=	1.00
APPLICATION	=	2.50
CHEMICAL MIX & APPLICATION	=	-0-
152 NH_3 @ $ 164.29 *	=	12.49
FARMER APPLICATION		12.50
TOTAL / ACRE		$ 54.92

DRY BLEND

500 Lbs. 5-15-25 @ $ 98.77	=	$ 24.69
MIXING $ 4.00 x 500/2000	=	1.00
APPLICATION	=	2.50
CHEMICAL MIX & APPLICATION	=	2.50
152 Lbs NH_3 @ $ 164.29 *	=	12.49
FARMER APPLICATION *	=	12.50
TOTAL / ACRE	=	$ 55.68

* APPENDIX B

The retail cost per acre of applied fertilizer is considered in three examples of fertilization programs : a single once-over application of N-P-K ; an application of N-P-K with an additional application of supplemental nitrogen from UAN ; and an application of N-P-K with supplemental nitrogen from an additional application of ammonia. The costs of these alternate programs are summarized in Figure 10.

The slightly favorable material costs of the Fluid Blend product and the easy incorporation of chemicals allow competitive pricing at higher gross margins. The Fluid Blend program can compete with dry blends in a once-over program and in the program using ammonia for supplemental nitrogen. In the program using UAN for supplemental nitrogen, the dry blend distributor can incorporate chemicals in the UAN solution, thereby reducing costs through combined applications. The Fluid Blend distributor can meet this more favorable retail cost by reducing his margin on the 5-15-25 mix to 25 %. In this example, his gross margin is still higher than the 22 % gross margin assumed for the dry blend product.

CAPITAL INVESTMENT COMPARISON

Figure 11 lists the estimated initial capital investment of a 3 000 nutrient ton per year Fluid Blend business designed for rapid growth through later addition of satellite distribution units. The total cost of facility and equipment with forty-ton per hour processing capacity is compared to a similar capacity and volume dry blend unit. A custom application program is assumed in each case. The initial total capital investment for the dry blend system is about 13 % less than that of the comparable Fluid Blend. The difference in investment results from the more costly mixing system required for Fluid Blend processing.

FIGURE 10

SUMMARY FARMER COSTS

PROGRAM 150-75-125	DRY BLEND	FLUID BLEND
ONCE-OVER	$ 55.52/A	$ 55.29/A
5-15-25 + UAN	$ 56.27/A	$ 57.01/A
5-15-25 + NH_3	$ 55.68/A	$ 54.92/A

FIGURE 11

PLANT INVESTMENT COMPARISON
(3000 NUTRIENT TON CAPACITY)

	DRY BLEND	FLUID BLEND
OFFICE	$ 30 000	$ 30 000
RAW MATERIAL RECEIVING	20 500	20 500
RAW MATERIAL STORAGE	77 000	77 000
SHOP & CHEMICAL STORAGE	25 000	25 000
MIXING, PRODUCT STORAGE AND LOADOUT	67 000	135 000
TRUCK SCALE	28 000	28 000
BUCKET LOADER	12 000	12 000
LAND & IMPROVEMENTS	46 500	48 000
APPLICATION EQUIPMENT AND TRANSPORT	150 000	150 000
TOTAL	$ 456 000	$ 525 500
DIFFERENCE		$ 69 500 * 13 %

ECONOMIC EVALUATION OF SPECIFIC PROJECT

In the previous discussion, the comparative costs and margins of suspension fertilizers have been considered from the viewpoint of manufacturer, distributor, and farmer. The discussion used examples assuming stated costs and margins to demonstrate techniques for comparative evaluation of alternative systems. The analysis is too general to develop specific conclusions. Agrico's experience has been that distributors following a Fluid Blend suspension program based on MAP can profitably compete with traditional dry blend programs.

Distributor economics must be developed on a specific project basis to be meaningful. Merchandising programs, market potential, growth and market share projections, competitive practices, investment and operating capital requirements, financing, and many other items must be evaluated for each specific situation to determine profit and risk potentials.

Agrico has recently evaluated a Fluid Blend distribution project in one of its retail markets. A market survey was made from which a merchandising program and market growth projection was developed. A market plan was defined and the plant design and equipment required to support it specified.

The pro forma first year profit and loss statement for this project is shown in Figure 12. In this project, a gross margin of 30 % of mixed fertilizers was planned, but a lower margin was expected on supplemental nitrogen. The gross margin on total fertilizer sales was expected to be 27 %, with gross margins of 12 % on chemicals and 14 % on seed. The initial capital investment required for this project is $ 618.200.

Market growth and investment requirements supporting it were projected along with operating costs and working capital needs for a 15-year period. Initial capital investment debt was retired during the first seven years and all subsequent investment assumed to be paid for out of current earnings. The discounted cash flow return on investment (DCF-ROI) was developed using a Net Present Value computer system. The project indicated a DCF-ROI of 20,8 %.

A sensitivity analysis was performed by evaluating the impact on the DCF-ROI by changes of plus-or-minus 10 % in : Selling price ; Volume ; Capital Investment ; and Operating Expense. The impact on DCF-ROI of a plus-or-minus 10 % change in these key variables is summarized in Figure 13.

In this analysis a change of 10 % in capital investment or in volume has relatively minor impact on indicated profitability measured as DCF-ROI. Changes in selling price and expenses directly affect gross margin of the business and have a major impact on profitability. This analysis suggests the importance of efficient and productive plants designed for low operating and maintenance costs. Although efficient plant design may require greater initial capital investment, this cost should be evaluated against the greater margins possible from more efficient operation. Economies of size are also indicated. Experience suggests an initial total annual business volume in the range of 5 000 tons generally develops a satisfactory profit and investment return. Business volumes significantly less than this level usually require more modest investment resulting in increased operating costs and limited capacity for business growth.

CONCLUSION

The popular market appel and merchandising advantages of fluid fertilizers have been demonstrated in the United States market. The sustained growth rate in use of fluids has exceeded that of total fertilizer consumption. Recent innovative suspension fertilizer technology has solved previous handling and distribution problems and eliminated the premium cost previously associated with most fluid fertilizer programs.

There is a definite trend to distribution of suspension fertilizers in the United States. The proven profitability and merchandising advantages of suspension programs suggest that this trend will be sustained.

This discussion has been general in nature and is intended to demonstrate techniques of evaluation for specific suspension distribution projects. These techniques have proven themselves in Agrico's Fluid Blend market development strategy. We hope that this discussion will be helpful in assessing the potential impact of MAP-based Fluid Blend suspension fertilizers in world markets.

FIGURE 12

AGRICO-FLUID BLEND PROJECT

PROFORMA P & L - FIRST YEAR

PRODUCT TONS		6 550
REVENUE		
FERTILIZER		$ 712 800
CHEMICALS		200 000
APPLICATION ($ 3/A)		104 220
SEED		70 000
DELIVERY INCOME		1 500
	TOTAL REVENUE	$1 088 520
CASH OPERATING EXPENSE		
COST OF SALES - FERTILIZER		$ 518 800
COST OF SALES - CHEMICALS		176 000
COST OF SALES - SEED		60 200
FIXED OPERATING EXPENSE		110 800
VARIABLE OPERATING EXPENSE		77 600
INTEREST - INVESTMENT & W.C.		89 000
	TOTAL EXPENSE	$ 1 032 400
PROFIT BEFORE TAX & DEPRECIATION		$ 56 120
TOTAL INVESTMENT		$ 618 200
DCF-ROI (15 YRS)		20.8 %

FIGURE 13

AGRICO FLUID BLEND PROJECT

SENSITIVITY ANALYSIS

	DCF RATE OF RETURN (%)
BASE CASE	20.8
SELLING PRICE : + 10 %	29.5
- 10 %	9.7
VOLUME : + 10 %	22.4
- 10 %	19.3
INVESTMENT : + 10 %	19.2
- 10 %	22.8
EXPENSES : + 10 %	10.4
- 10 %	29.2

APPENDIX A

MONO-AMMONIUM PHOSPHATE (MAP) VERSUS OTHER SOURCES

In many cases, the selection of a fertilizer P source is not of major importance. There are many research reports that conclude that one P source is equal to another over a rather wide range of conditions. The important decision in these situations is to apply proper rates of P according to soil test results. Source preferences are sometimes made for non-agronomic differences /19, pages 95-97/.

However, there are certain conditions where a particular type (source) of P can be agronomically better than others. This will depend upon specific crop-soil-placement factors. The following review is concerned with "special use" situations where MAP (mono-ammonium phosphate) can be equal to and often superior to other fertilizer P sources.

Young and Hicks /1/ summarized the properties of MAP in 1967 as follows : "Mono-ammonium phosphate has agronomic advantages in some types of uses. Agronomic tests by TVA personnel show that mono-ammonium phosphate does not form apatite by reaction with calcium in soils as diammonium phosphate does, and that loss of nitrogen after surface application on calcareous soils is less with mono-ammonium phosphate than with diammonium phosphate. Also, use of mono-ammonium phosphate on nonacid soils results in increased response to phosphates because the soil is acidified. There has also been some interest in adaptation of the process because of the higher percentage of P_2O_5 in the granular mono-ammonium phosphate (55 % vs. 46 %) where storage and shipment of a good quality phosphate product are primary objectives".

The work referred to by Young and Hicks included comparison of AS, Urea, SU, UAP, AN, APN, MAP, and DP/2/. This work showed that adding phosphate to surface applied urea on near neutral to alkaline soils reduced N losses. Severe N loss also was noted with similarly surface applied N when AS or DAP were the N sources. Maximum N recoveries were obtained with MAP, AN, APN, and APP under these test conditions. The reaction of NH_4-N sources with Ca in the soil was related to N losses. Terman and Hunt stated "Thus, MAP was equally or more effective at all pH levels for supplying N to corn than other source". Work reported much later by Fenn of Texas /3/ demonstrated that mixing as little as 30 % MAP in a fertilizer blend could reduce NH_3 losses from ammonium N sources that are surface applied to calcareous soils. The soil reaction responsible for NH_3 losses with surface applied ammonium N sources was listed as being

$$(1)\ NH_4^+ \text{-N} + CaCO_3 \text{ soil} \xrightarrow{H_2O} CaSO_4 . 2H_2O + (NH_4)_2CO_3$$

The ammonium carbonate formed by this calcareous soil reaction is unstable and forms NH_3 + CO_2 gases that can be lost through volitilization if surface applied. The TVA work showed that DAP + DP added with the NH_4 - N source urea could reduce the amount of $(NH_4)_2CO_3$ formed and thus reduce NH_3 losses. With MAP added (rather than DAP), different reaction products were formed that also prevented NH_3 losses. APP also formed different reaction products in soils, but it like MAP formed meta-stable reaction products that indicate an advantage of these fertilizers over DAP, Urea, and AS as sources of N on neutral to calcareous soils.

MAP VERSUS DAP : Other studies /4/ disclose that the pH of the soil solution with MAP is lower that that formed with DAP (about 4.0 with MAP compared with about 9.0 with DAP). The higher pH with DAP, reversion to water insoluble forms of soil P is greater when applied to calcareous soils.

MAP VERSUS APP : Spratt /5/ found APP to be slightly superior compared with MAP with wheat by continuing grain development period a longer period. Others found APP to be equal or slightly superior to MAP, possibly because of improved micronutrient uptake /6/. However, Dobson /7/ found no differences between effectiveness of MAP and APP and found no difference in Zn uptake /7/.

Mobility of P sources in soils has been studied by Hashimoto and Lehr /8/. The total distance of P movement in soils as well as distribution patterns of water-soluble P were similar for ortho and poly P forms studied. The theory that less "fixation" would occur with APP sources of P (as compared with ortho sources) was disproved by Lehr et.al. Yet in still another Iowa study reported by Subbarao and Ellis /9/, plants given APP grew less than if given DAP. Here reaction products of polyphosphates formed an unavailable reaction product on high pH, calcareous soils.

Engelstad and Allen /10/ of TVA found TPP to be less effective than MAP for corn when mixed through the soil on cool soils, but equal on warm soils or in bands. About half of the P in APP is TPP. These authors quote work by Gilliam where two sources were equally effective P sources.

Dr. Everett J. Dennis writes that "Polyphosphates are somewhat superior to orthophosphate, from my experiences in the normal alkaline soil ranges. Polyphosphates are limited in the very acid and very alkaline soils." He describes "very alkaline" soils at pH above 7,9. He states poly and orthophosphates are equal at pH 5,8 to 7,0. By difference, at pH's 7.0-7.9, I conclude that Dennis feels the poly source has an advantage because of micronutrient complexing ability. He states that at the extremes in pH's, the biological reactions to hydrolize polyphosphate to plant available orthophosphates are limited, thus reducing effectiveness of the poly source. Dennis also points to the possible NH_3 release from DAP alkaline soils (that can reduce seed germination and increase N loss) that does not occur with MAP or APP.

Miller's work /12/ indicates that lower pH's with MCP + $(NH_4)_2SO_4$ prevented the precipitation of $Ca-PO_4$ on root surfaces thereby causing the observed increase P uptake with $(NH_4)_2SO_4$. K_2SO_4 did not. The lower pH associated with MAP could also achieve the same situation in fertilizer bands.

Studies by Bouldin et al. /13/ reveal that larger particles of water-soluble P sources such as MAP are most available to plants. This would be a "plus" for AGRICO's granular MAP.

Chemical compatibility of MAP is excellent. TFI's manual /16/ shows it to be compatible with AN, Urea, AS, Triple, 0-20-0, CAP, KCl, and K_2SO_4. DAP is of "limited" chemical compatibility with single and triple superphosphates.

Toxicity hazard with DAP is greater than with MAP, especially on high lime, sandy soils /18/ according to early work reported by Allred and Ohlrogge. Root growth was also less with DAP than with MAP in sandy soil, but little difference was noted in finer textured soil.

Sample and Meredith of TVA summarized agronomic aspects of MAP at the 1975 TVA Fertilizer Conference held in Louisville /19/. They show why MAP is a better P source because : (1) it is an excellent blending material, (2) it is more flexible than DAP for blends, (3) MAP is better than DAP for blending with Urea for pH reaction reasons, and this reduces the final blend's toxicity and N-loss potentials, and (4) MAP is clearly better than DAP on calcareous soils for several reasons (as discussed elsewhere in this summary report).

Others have compared P sources with respect to their properties concerning the uptake of certain micronutrients. MAP (and urea) were found to be effective carriers of $ZnSO_4$, but not ZnO /15/. Reason is that they fail to solubilize the ZnO. APP did. MAP with $ZnSO_4$ produced more growth of corn with higher Zn content than APP in quoted work by Terman (1966). However, MAP and urea are about 50 % as effective as APP with ZnO.

Kansas data by Adriano and Murphy /17/ show MAP (banded) was better than APP if no zinc is added, but the MAP and APP were equal if adequate Zn was added. Yield and element levels were used as criteria. The authors quote several references where APP would be better than MAP as a P source, vice versa, and "no difference" situations. MAP and APP were equal in P uptake in the Kansas study and both were better than TSP. In this study MAP and APP had equal effects on increasing Mn uptake. Similar effects were quoted on carrier influence on plant Mn uptake (in Michigan with soybeans).

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APPENDIX B

T.V.A. DATA ON NH_3 APPLICATION COSTS PER ACRE

Summary of anhydrous ammonia delivery, application and investment conditions, and costs per acre for nine Iowa and Nebraska dealers and their farmer customers, 1974.

Dealer	Average Length of Haul	Average Application NH_3/Acre	Investment/ Acre of Annual Application	Delivery and Application Cost/Acre
	Miles	Pounds		
A	20.00	170	$ 5,63	$ 2,84
B	5,00	152	6,47	3,00
C	14,00	138	1,99	2,18
D	6,00	100	3,86	1,45
E	8,00	165	4,92	2,62
F	7,00	200	13,40	4,39
G	20,00	152	2,32	2,59
H	15,00	200	4,53	3,08
I	30,00	100	2,77	2,60
Average	13,90	153	5,10	2,75

1978 Investment/Acre Compared to 1974 Acre -	Depreciation	+ 68 %
	Maintenance	+ 60 %
	Insurance	+ 68 %
	Taxes	+ 28 %
	Interest	+ 88 %
	Labor	+ 52 %
	Fuel/Oil	+ 35 %
	Equipment	+ 70 %
Delivery and Application Costs 1978 Compared to 1974 -		+ 65 %

Applying these changes we get average increase of 60 percent for investment. The rate of NH_3 increased from 153 to 180 Lbs.per acre; the average tonnage increased from 2 500 to 3 000 so that the number of acres remained almost the same.

Average Investment Cost per Acre = 5,10 x 1,60 = 8,16

Average Delivery & App. Per Acre - 2,75 x 1,65 = 4,53

Possible Total Cost Per Acre 12,69

TVA Data Updated by Agrico Chemical Company
September 11, 1978