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FERTILIZER INDUSTRY
ROUND TABLE
1995

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Table of Contents

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Opening Remarks

Walter J. Sackett, Jr., Chairman

Good morning Ladies and Gentlemen. Welcome to the 45th Annual Meeting of the Fertilizer Industry Round Table. I am Walt Sackett of the A. J. Sackett & Sons Company and I'm serving as Chairman of the Organization this year. Chairman, that's the honorary title they give Paul's assistant.

I've attended every one of these meetings since 1956 and that's not any record. We've got a man with us today who is attending his 45th meeting. One of the founding fathers, Joe Reynolds. Joe, please stand up and take a bow.

Joe typifies the kind of dedication that made the Round Table thrive during the granulation years of the 50's & 60's and be flexible enough to serve the wide aspects of today's industry. The only way that the organization can do that, is by drawing from the vast pool of knowledge that we have in our Board of Directors. Our Board is composed of dedicated men and women that selflessly give of their time and talents to make the Fertilizer Industry Round Table the respected Organization that it is. Twice a year these folks congregate in Baltimore for the sole purpose of hammering out a diverse and meaningful program. And they do it! I think that you'll agree with me that we've done it again this year.

Now I would like to introduce one of those dedicated young men, Mr. Pat Peterson, Manager of Special Services for C.F. Industries who will introduce our Keynote Speaker.

Monday, October 23, 1995

Session I
Moderator:

Patrick E. Peterson

Keynote Address

Thomas J. Wright
PCS Phosphate Company, Inc.

Thank you, Don, for that kind introduction. I would like to join Don in welcoming you all to Raleigh, and thank you for inviting me to present my thoughts on the current state and future of the world fertilizer industry.

We've come through an interesting and turbulent period in our industry, during which we experienced oversupply, underconsumption and much more. In the decade leading up to 1988, there was optimistic expansion followed by oversupply throughout the fertilizer industry. The crash came in 1989. Consumption suffered a triple blow over the next five years. It collapsed in the Former Soviet Union and Eastern Europe when they moved to market economies; it was affected by reforms to the European Union's agricultural policy; and it also suffered as subsidies were removed in many developing countries.

I believe that what has evolved through these five tough years is a stronger, more viable and efficient industry. Those fertilizer producers that have survived are now in better positions to serve the growing demands of a hungry world, and the future looks brighter for our industry.

Much the same changes have taken place across the ertire fertilizer industry—N, P and K —in the last five years. But my talk is particularly about potash and phosphate, the two products of my company, Potash Corporation of Saskatchewan, which have had similar experiences during the past decade. And it is about the present and future of our industry.

I want to talk first about phosphate, the sector of the industry which I know best; but ,as we will see, events were also reshaping the potash industry.

In 1988, world phosphate consumption on a P_2O_5 basis was 38 million tons. Five years later, in 1993, it had fallen to 28.6 million tons — that's a staggering 25 percent decline. Most of that unprecedented decline took place in the FSU and Europe, where consumption was down by nearly 9.5 million tons. But during this period Chinese consumption was both up and down; it fell by 2 million tons P_2O_5 from 1991 to 1993 because of subsidy removal and currency devaluation. In that same period, India's removal of subsidies affected its consumption, which went down by 0.7 million tons. In March 1993, DAP prices hit a 20-year low.

Similar events took place in potash, for the same reasons, though prices did not fall quite so badly. Consumption dropped a third from 52 million tons product in 1988 to 34 million tons in 1993. Like phosphate, most of that drop took place in the FSU and Europe.

I now want to tell you a tale of two companies which came through this difficult five years, somewhat differently and not easily, for nothing was easy then—but both were profitable. The key is that both responded successfully to the challenges, by adapting, and remained strong and important in their sectors of our industry. They became one, even stronger, company earlier this year, Potash Corporation of Saskatchewan. It's the world's largest potash company, with 22 percent of world capacity; and, with the pending Occidental Chemical purchase, the third largest phosphate company, with 19 percent of world capacity.

I begin with the company I am most familiar with, which is PCS Phosphate. Until April it was Texasgulf, and was owned by Elf Aquitaine. PCS Phosphate is a large low-cost producer with 75 years of excellent reserves. It is the world's largest vertically-integrated phosphate mine and processing complex at one site, which minimizes transportation and reclamation costs. It is an important player in the animal feed market, and a leader in land reclamation and environmental awareness.

We are the only U.S. phosphate company participating in all major markets. During the tough times for our industry, we took a good percentage of our acid out of fertilizer and funneled it into animal feed and industrial products. These non-agricultural products are now 29 percent of our business but contribute 40 percent of revenues, and they buffered us through those tough times. Through the bad years for the fertilizer industry, we always made money.

PCS, too, was profitable through the five years of downturn. It is a former Saskatchewan Crown corporation which lost $100 million in 1986. Chuck Childers joined the company in 1987, and the next year it made a $100-million profit; that represented a $200-million turnaround on $300 million in revenues.

PCS became publicly-traded in 1989, the year when what had been a growing potash market suddenly went into a decline, just like phosphate markets. Nonetheless, PCS held to its strategy of matching production to demand, and its low-cost production and inventory control enabled it to reap a growing share of world sales. It actually increased its earnings over this five-year period; and, when world conditions turned around in 1994, increased both volumes and earnings.

It has become a potash powerhouse since 1989, through a series of strategic purchases and agreements to handle offshore sales for New Mexico companies. It now owns 14 percent of world production, 22 percent of capacity and 40 percent of excess capacity, and is involved in 80 percent of North American potash exports. PCS has reserves for over 100 years of production. It has been profitable for its shareholders every year since it became publicly-traded. In these circumstances, with growing export markets, a well-established domestic market and an excellent financial position, it turned its attention to phosphate.

You can see that with their similarities in quality reserves, assets and people, and their matching promise, the marriage of PCS and Texasgulf was made in heaven—or at least in Paris, which is pretty close to heaven here on earth, especially in the spring when the agreement was finally signed.

Through the years of growth in demand, up to the record year of 1988, and the subsequent crash through 1993, the ups and downs in potash and phosphate consumption paralleled each other, as we have seen. The downturn in 1988 was the first major decline in demand in the fertilizer industry's history.

In the past, when phosphate or potash supply and demand came into balance, supply was expanded. The industry had tough times until demand caught up, and then the cycle began again. But this latest decline in industry profitability was demand-induced.

There were some benefits to this unprecedented drop in demand, for the industry responded through closures and consolidation. Many government-owned companies have been privatized in the last few years. Others owned by mining or chemical companies became publicly-traded in their own right. Fertilizer companies are now stand-alone and they make their business decisions according to the bottom line for shareholders. They are profit-oriented.

New projects must be justified today on commercial grounds. In phosphate, the only projects to get the go-ahead are those which can be funded internally. Joint ventures between suppliers and consumers are being explored as other options. Plants relying on commercial funding have been unable to proceed. In the United States, increased environmental regulation has boosted construction costs. Environmental restrictions, coupled with better availability of cheap imports, led to the closure of considerable acid capacity in Western Europe.

Equally in potash, new developments are unlikely, because of costs and current capacity. PCS, for example, has never used all of its capacity of more than 11 million tons KCl, and can bring it on stream with little capital outlay when circumstances warrant.

All these developments make for an industry more attentive to the bottom line and return to shareholders.

Now it is late in 1995 and the fertilizer industry is getting back on track. World fertilizer consumption rose in 1994; from the low of '93, we calculate that potash demand was up 12 percent and phosphate consumption 3 percent. DAP export prices today are roughly double what they were in the spring of 1993, which was a 20-year low. After rising and falling throughout the '90s, though never as much as phosphate prices, potash export prices are now the highest in over a decade.

We're anticipating some increase in consumption this year, too. There are signs of hope for increased usage in the FSU, and Eastern European farmers are applying more fertilizer. Western European demand has stabilized now that the EU agricultural reforms are in place. But the recovery that began last year was led by the resurgence of demand in the developing nations, and that is where the future promise lies.

At PCS, we have identified three bellwether nations, China, India and Brazil, and we pay particular attention to them.

China is the largest offshore market for both potash and phosphate. Its economy is growing by roughly 10 per cent a year, and it is coming to grips with its agricultural problems. As you can see in this graph, its trend line for fertilizer use is up. Eight months into 1995, it had broken its '94 record for purchases from Canpotex, the marketing agency for all Saskatchewan potash producers. It imported about 4.8 million tons of phosphate last year, more than one-third of world imports, and we expect about the same volumes, or more, this year.

India increased its consumption of both P and K in 1994, after it reinstated, on an ad hoc basis, the subsidies whose removal had such a strong effect the year before. We anticipate that India will purchase more potash and more phosphate this year. As this graph shows, its phosphate purchases vary between DAP and acid. Depending on several factors, particularly fertilizer subsidies, it may buy acid to make DAP, or buy DAP. We anticipate further growth in this market regardless.

As the leading economy in Latin America, Brazil is an influential fertilizer market. Its imports of both potash and phosphate have risen steadily since 1991. It imported record volumes of potash in '94, and we expect nearly as much this year, now that product is moving again after a pause caused by government policy on interest rates in the agriculture sector. It is the third largest phosphoric acid importer and a major TSP and MAP purchaser.

These three large countries have enormous influence on fertilizer markets, as we saw when they introduced a variety of agricultural reforms because of domestic economic problems. But they are just part of a picture of growing need for fertilizer in many developing nations, a need that reflects the growing world demand for food. We expect world food demand to double in 30 years.

Despite wars, famine, increases in death rates and decreases in birth rates around the globe, world population continues to grow, by about 100 million new mouths each year. It will grow by about 3,800 during the 20 minutes I am talking. The experts forecast that in just 10 years, the world will be home to more than 6.6 billion people. More than 90 percent of this projected growth will take place in developing countries, including China.

Of course, there are wide differences among countries in per capita food consumption, usually for economic reasons. We are advised that most of the population growth of the next decades will take place in the developing countries that are at the lower end of the scale in per capita food consumption.

History shows that as people become economically more secure, they want better food and more of it. The number of developing countries with rising discretionary income continues to grow. China leads the way, but Korea, India and other Asian countries also continue to prosper and grow. Mexico, Brazil, Argentina and other Latin American countries are also showing progress. Diets have improved, and will continue to improve.

Despite good crops in many countries in the last few years, world grain inventories as a percent of consumption have fallen below the level of 1972/73, when the situation was described as a "food crisis." USDA reported recently that grainstocks will be 14.5 percent of use at the end of the 1995-96 crop year, down from 17.4 percent at the end of the current year. Existing grainstocks will provide only enough food for about 52 days.

We believe that the world's breadbasket in the future will look much like today's, only bigger. North America, Western Europe, Australia and Argentina will continue to export their surplus agricultural output into an ever-expanding global marketplace. WEFA's current forecasts indicate that the world grain trade will grow from today's 205 million tons to over 250 million tons by 2005.

The secret to meeting the food needs of tomorrow is no secret at all. Since there is no more good, untouched land available, the land that is in production must produce more. That can't happen without the proper use of fertilizer. We cannot maximize production unless we apply nutrients in the proper quantities and at the right times. And unless we maximize production, we cannot feed the rising world population and all those who clamor for better food. The link between food demand, food production and fertilizer consumption is undeniable.

In 1932, the year I was born, the U.S. cropland was about 150 million hectares. It remains essentially the same today. Since that time, the American population has more than doubled and the U.S. is the leading exporter of grains. So we have more Americans eating more, and we still have more grains to export, produced on the same amount of land.

Modern agricultural technology, including the proper use of fertilizers, is what accomplished this amazing improvement in productivity. Without those improvements, at least 150 million more hectares of cropland would be required in the U.S., at the expense of the natural environment of forest, meadow and wetlands.

Without fertilizer, the world cannot be fed. It's as simple as that. We are in the right industry, my friends. It is an industry of great value and promise.

It was on the basis of that promise that PCS recently acquired the agricultural products division of Occidental Chemicals. Its purchase, which will be completed when the waiting period under the Hart-Scott-Rodino Act expires, doubles the size of PCS Phosphate, the fourth largest phosphate producer in the U.S.

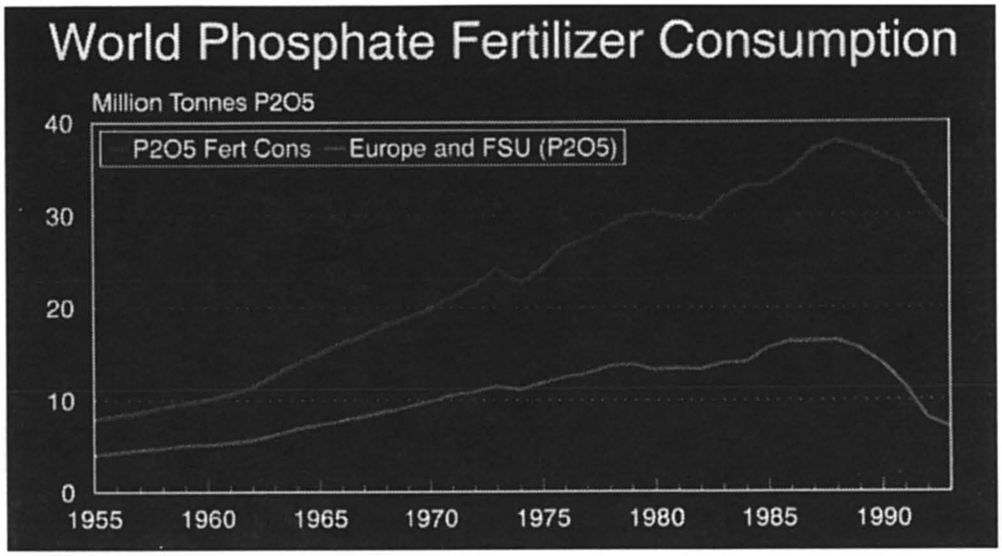
What we have bought is primarily a phosphate facility in northern Florida which produces fertilizer and feed products, and has an annual capacity of 1.2 million short tons P_2O_5. Its rock mining capacity is 4 million short tons per year with 20 to 25 years of reserves, depending on the mining rate.

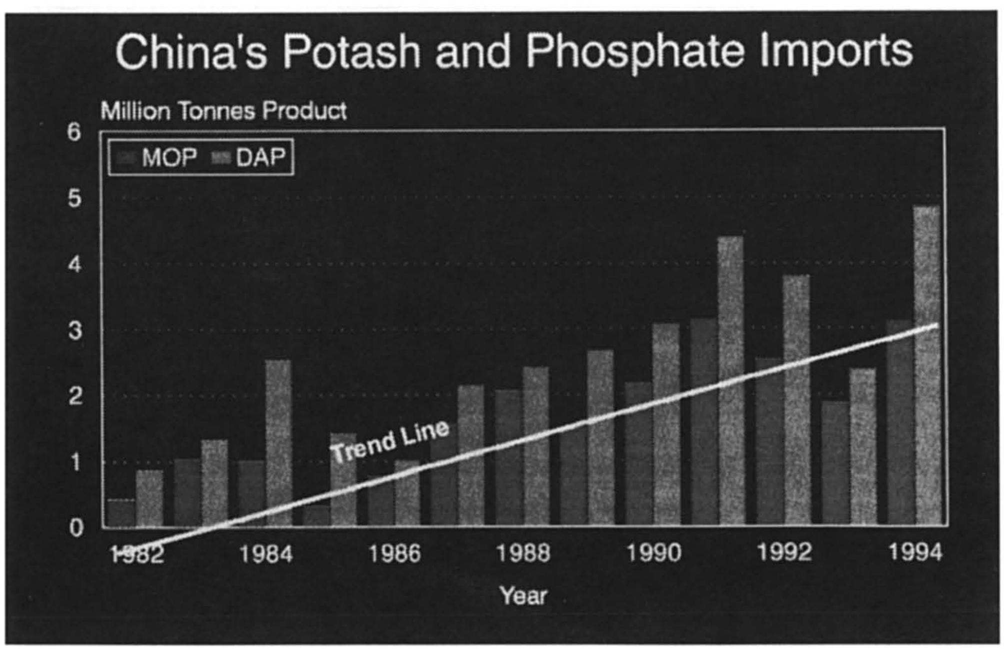
We are acquiring only the operating assets, and will pay $280 million, which includes $80 million in working capital. This is less than one-quarter of its estimated replacement cost. We expect it will fit well into PCS Phosphate. There are many synergies, including selling and administrative costs, the further strengthening of our transportation system, and increased sourcing and shipping flexibility. We expect it will enable us to buy sulphur and ammonia more cheaply, reducing the current costs of those inputs and increasing margins. It was also a consideration that we could likely ship rock from Aurora economically for production in Florida, extending reserve life there.

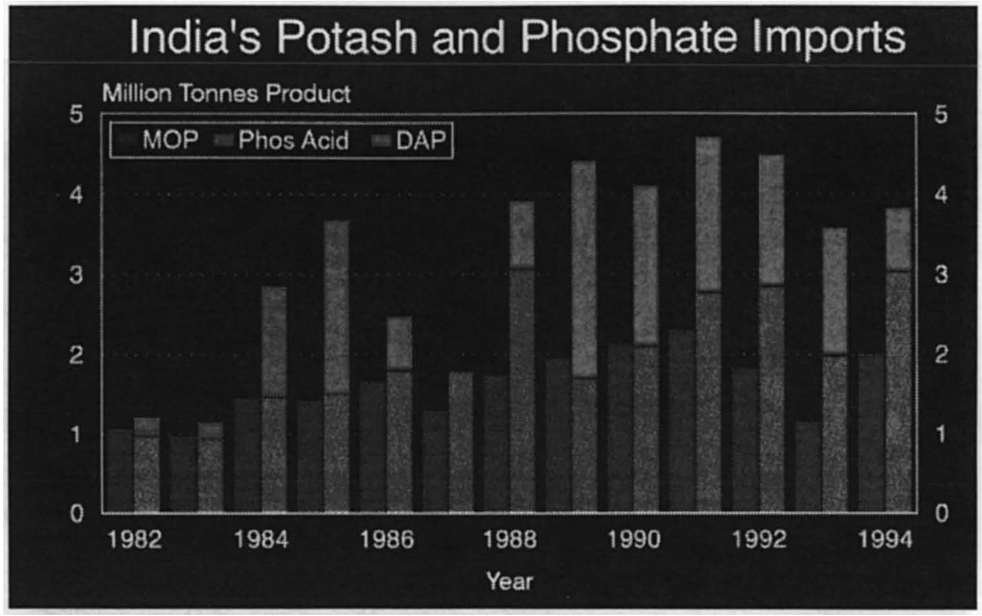
This purchase builds on our phosphate strength and consolidates our position as the second largest phosphate operator in the U.S. and the third largest in the world. We are equally consolidated in potash. In this way, PCS exemplifies the response of the fertilizer industry to the challenges of the last five years. We are bigger, stronger, more able to cope with and endure the vagaries of markets which can be affected by events totally outside the agricultural sphere. Our mood is upbeat, for we are a major player in a crucial industry.

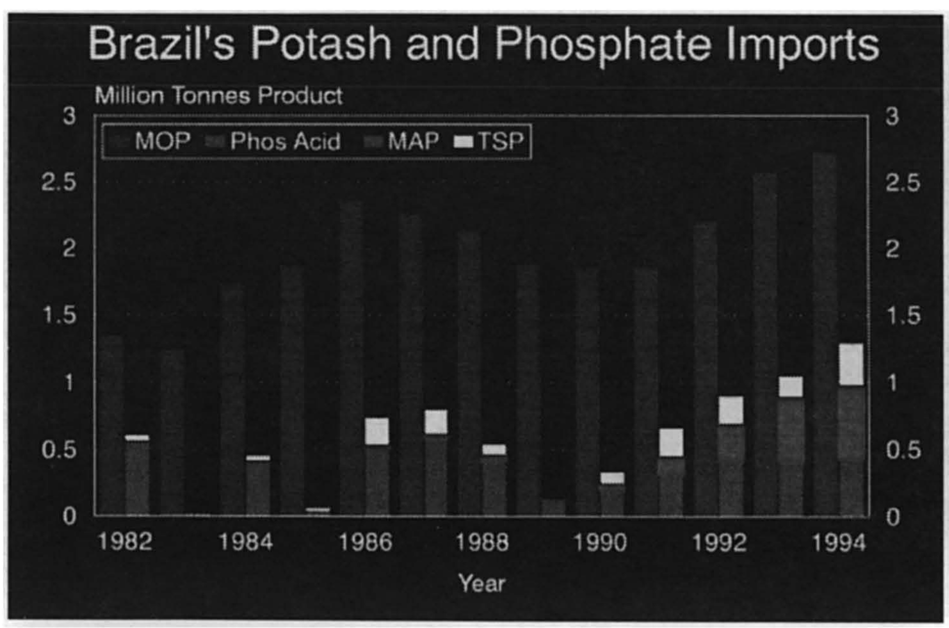
We in the fertilizer industry need to be strong and forward thinking to meet the challenge of helping the world feed itself. Prudent, cost-effective supply of plant nutrients must be timed to meet future market demands in a world that is far more sensitive to the impacts of our industry, both economically and environmentally.

For the first time in over a decade, we can realistically be optimistic about the future of the fertilizer industry. While we help the world feed itself, we help ourselves and our shareholders.






India's Potash and Phosphate Imports
Million Tonnes Product
MOP
Phos Acid
DAP
0
1
2
3
4
5
1982
1984
1986
1988
1990
1992
1994
Year


Brazil's Potash and Phosphate Imports
Million Tonnes Product
MOP
Phos Acid
MAP
TSP
0
0.5
1
1.5
2
2.5
3
1982
1984
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1988
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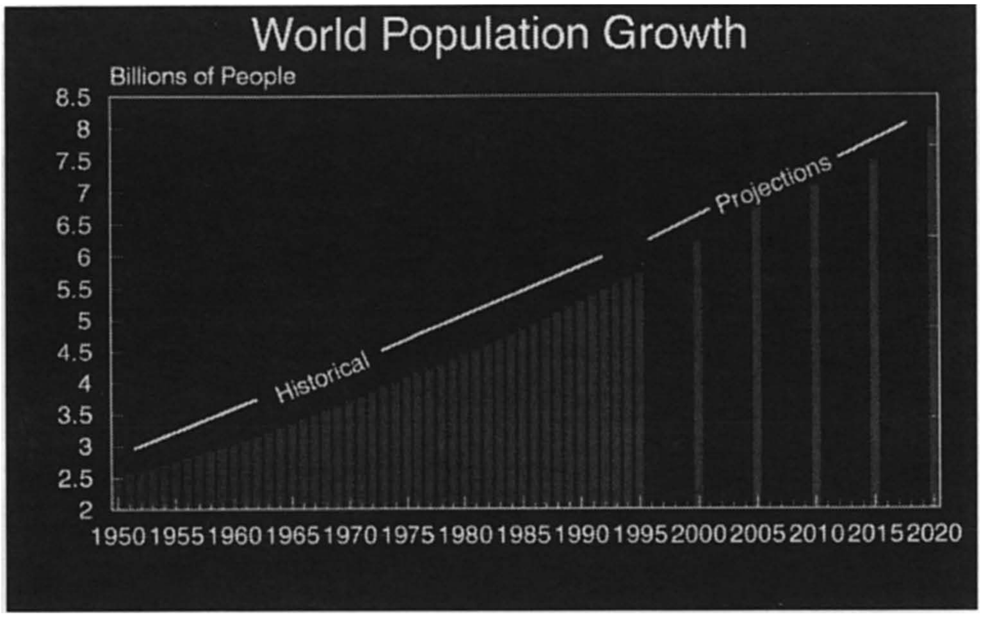
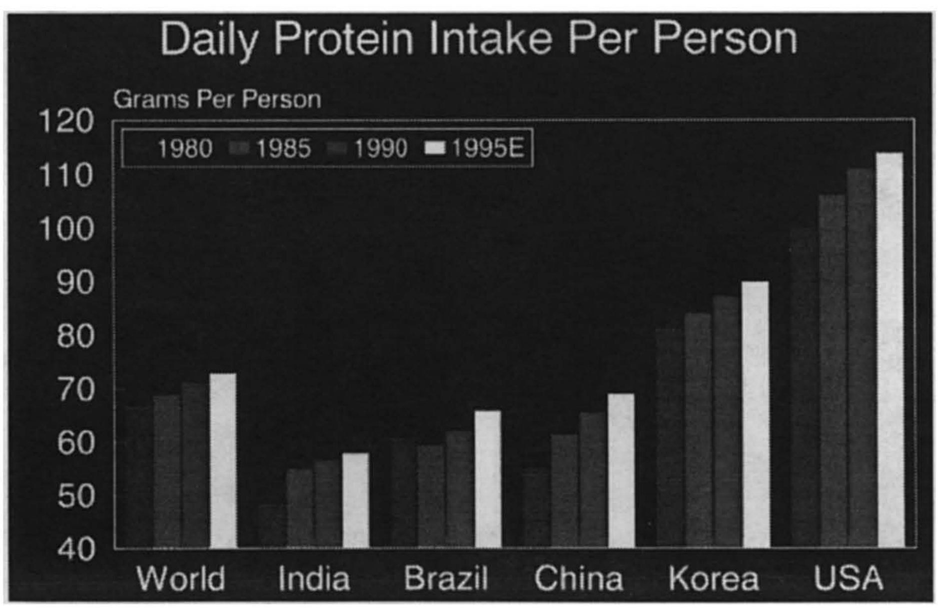
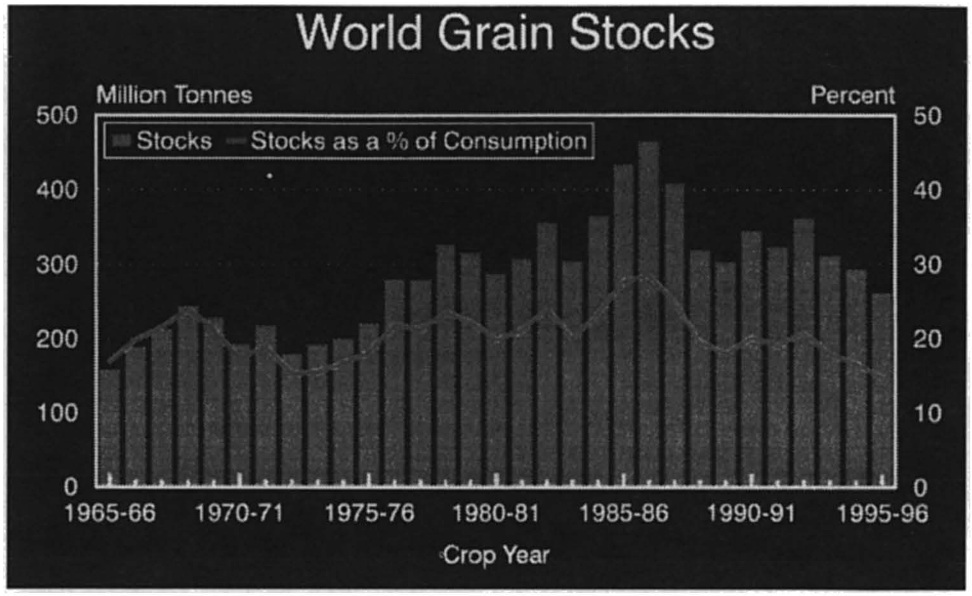
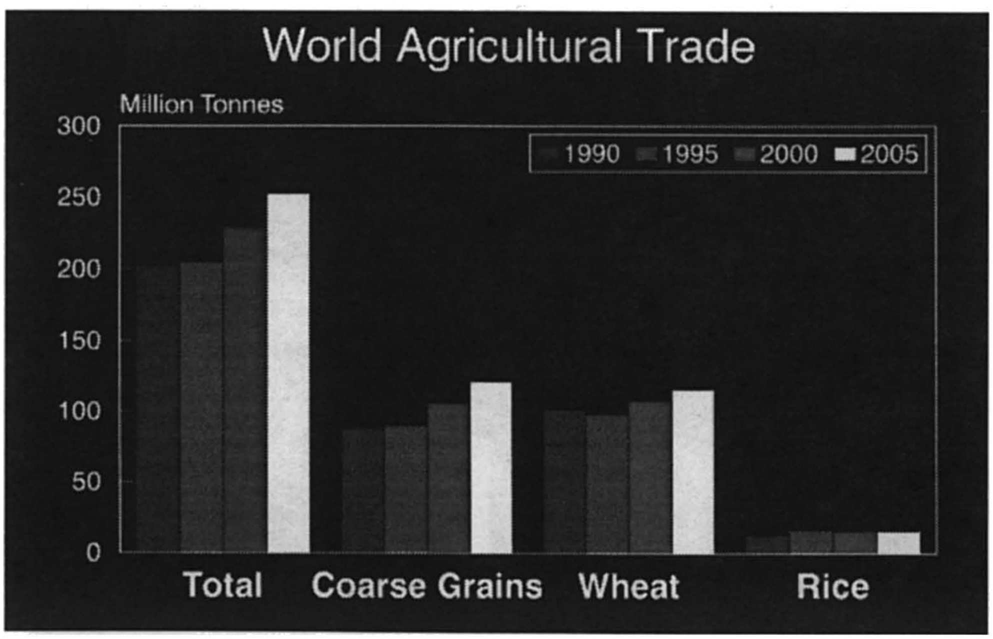
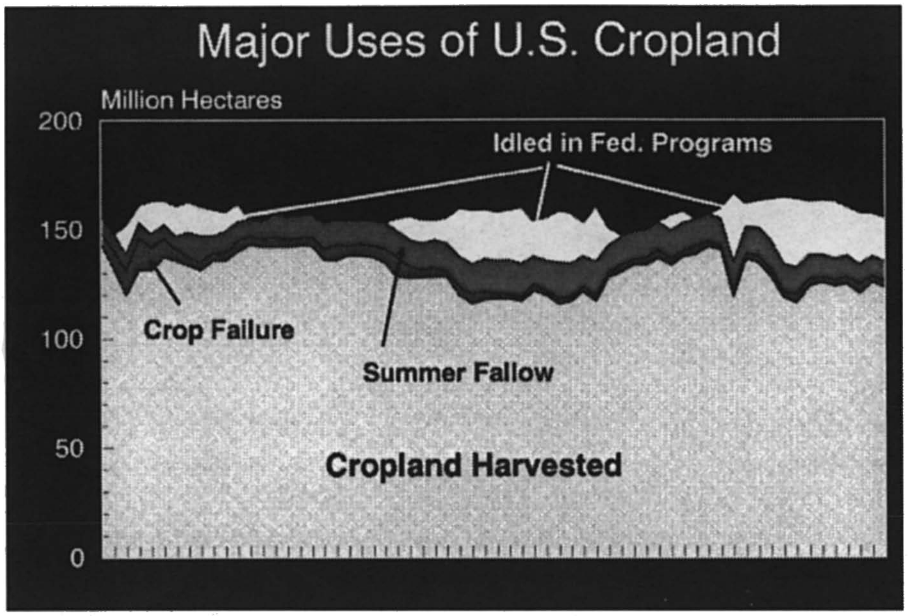
1992
1994
Year


World Population Growth
Billions of People
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
Historical
Projections


Daily Protein Intake Per Person
Grams Per Person
120
110
100
90
80
70
60
50
40
1980 1985 1990 1995E
World India Brazil China Korea USA


World Grain Stocks
Million Tonnes
Percent
Stocks
Stocks as a % of Consumption
500
400
300
200
100
0
50
40
30
20
10
0
1965-66
1970-71
1975-76
1980-81
1985-86
1990-91
1995-96
Crop Year


World Agricultural Trade
Million Tonnes
1990
1995
2000
2005
300
250
200
150
100
50
0
Total
Coarse Grains
Wheat
Rice



Major Uses of U.S. Cropland
Million Hectares
200
150
100
50
0
Idled in Fed. Programs
Crop Failure
Summer Fallow
Cropland Harvested

Outlook For Nitrogen

Richard D. Harrell
Terra Nitrogen Corporation

THE FERTILIZER INDUSTRY ROUNDTABLE
1995 ANNUAL MEETING

NITROGEN OUTLOOK

RALEIGH, N.C.
OCTOBER 22-23, 1995

Terra NITROGEN

U.S. PLANTED ACREAGE
(Million Acres)

	1994	1995	1996 Projections
Corn	79.1	71.3	81.0
Wheat	70.5	69.1	74.0
Other Feed Grains	23.5	22.3	23.0
Cotton	14.1	16.7	15.8
Rice	3.4	3.1	3.6
Soybeans	61.9	62.6	63.0
Other Crops	73.4	72.1	72.0
TOTAL	325.9	317.2	332.4

Terra NITROGEN

TERRA NITROGEN CORPORATION
TVA U.S. NITROGEN CONSUMPTION DATA
(Million Tons)

	ESTIMATE 1994-1995			ESTIMATE 1995-1996		
	PRODUCT TONS		TONS OF N	PRODUCT TONS		TONS OF N
AMMONIA	4.4	-21%	3.6	5.6	28%	4.6
UAN	8.4	-9%	2.5	9.4	13%	2.8
UREA	3.7	-8%	1.7	3.8	3%	1.7
SUBTOTAL			7.8			9.1
ALL OTHER N			3.5			3.4
TOTAL N CONSUMPTION			11.2 -11.7%			12.5 11.9%

CONSUMPTION NUMBERS ARE AS APPLIED TO THE FIELD. UREA, UAN AND AMMONIA USED IN BLENDS ARE SHOWN IN NP, NPK AND NK SECTION; NOT IN THE UREA, UAN AND AMMONIA CATEGORIES.

Terra NITROGEN

1995-1996 Crop Outlook Summary

- Higher 1996 Corn Acreage virtually assured. Est. 81 MM Acres
- USDA will Elect 0% set-aside for 1996 Corn Acres
- Wheat inventories Tight-Low Spring plantings. 1996 Acres to 74 MM
- Cotton Acre Reduction of 15.8 likely in 1996
- Rice Forecast 3.6 MM Acres in 1996.
- Acres planted in 1996 332.4 MM vs 318 MM in 1995
- 1996 N Consumption/Acre Corn 125 lb/acre vs 116 lb/acre in 1995
- Tons of N consumed for Corn in 1996 5.1 MM, 22% above 1995
- 1996 U.S. Nitrogen consumed will increase by 12% over 1995

Terra NITROGEN

Today's Ammonia Nitrogen Environment

- Tightening World Supplies
- Strong U.S. Industrial Demand
- Good Agricultural Fall Demand
- Stable to Up World Demand

What Caused This Current Situation ?

- Strong Demand driven by High Production Rates for DAP
- Production Problems - Plant Turnarounds
- Industrial / Petrochemical
- Ammonia Imports
- FSU / Ukraine Gas Costs

What Are The Effects ?

- Higher World Prices
- Higher FOB Gulf Prices
- Higher FOB Mid-West Prices
- Higher FOB Tampa Import Prices

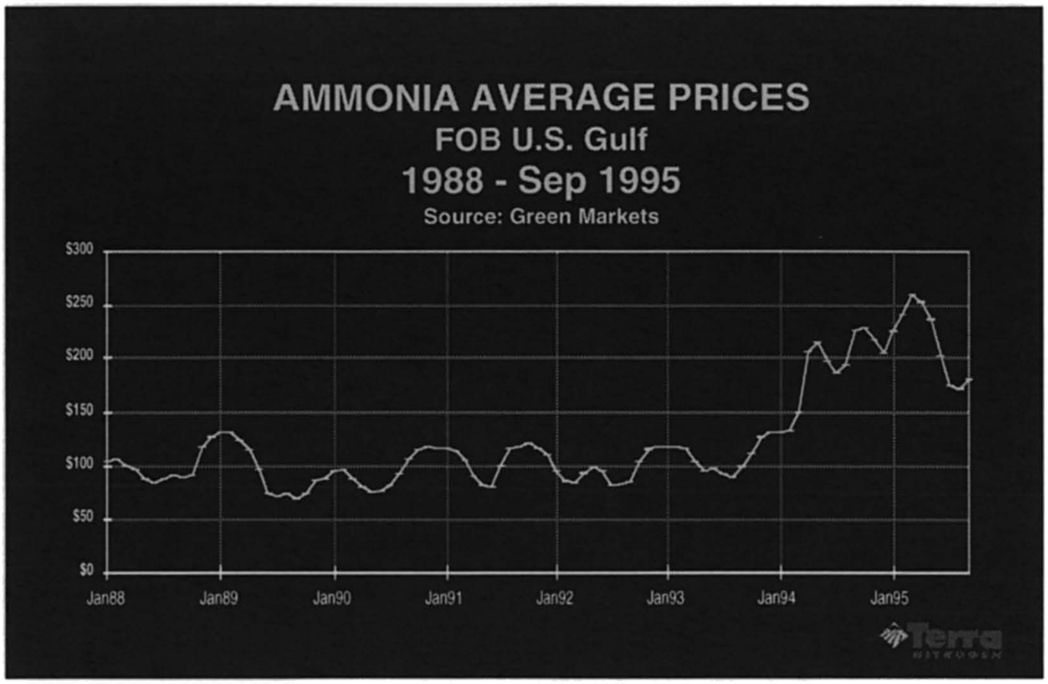
AMMONIA SPOT AVERAGE PRICES

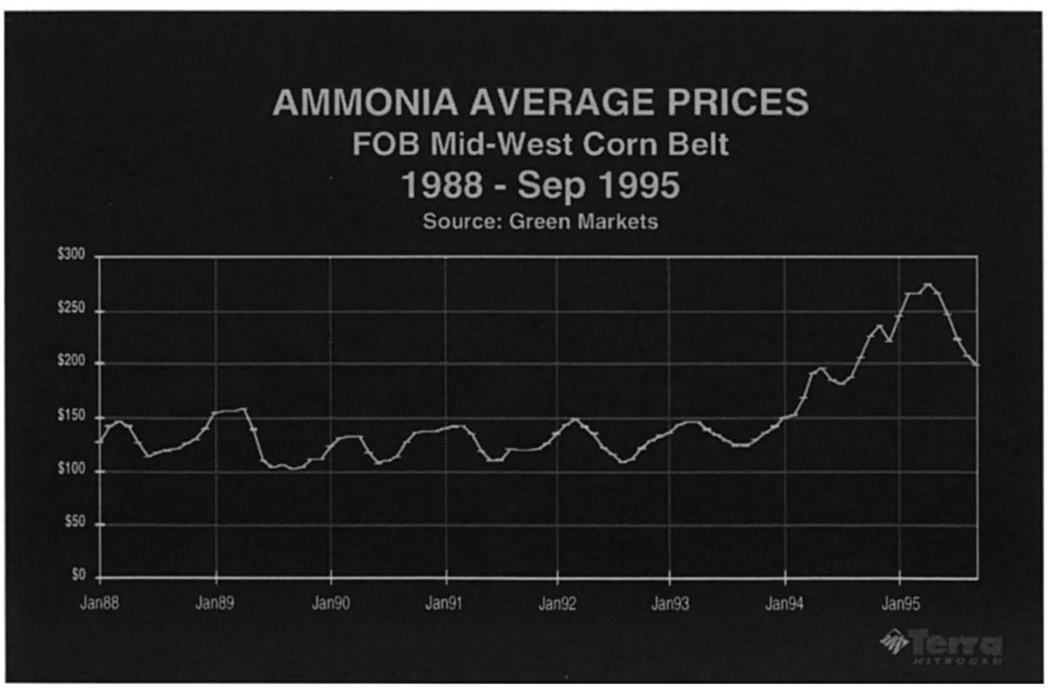
$/tonne FOB Cash

U.S. Domestic Price - $/S.Ton FOB NOLA Barge

1991 - 1995

Source: Fertecon


AMMONIA AVERAGE PRICES
FOB U.S. Gulf
1988 - Sep 1995
Source: Green Markets
$300
$250
$200
$150
$100
$50
$0
Jan88
Jan89
Jan90
Jan91
Jan92
Jan93
Jan94
Jan95
Terra
NITROGEN


AMMONIA AVERAGE PRICES
FOB Mid-West Corn Belt
1988 - Sep 1995
Source: Green Markets
$300
$250
$200
$150
$100
$50
$0
Jan88
Jan89
Jan90
Jan91
Jan92
Jan93
Jan94
Jan95
Terra
NITROGEN

Future ?

New Ammonia Capacity

Ammonia Price Projection (World / USA)

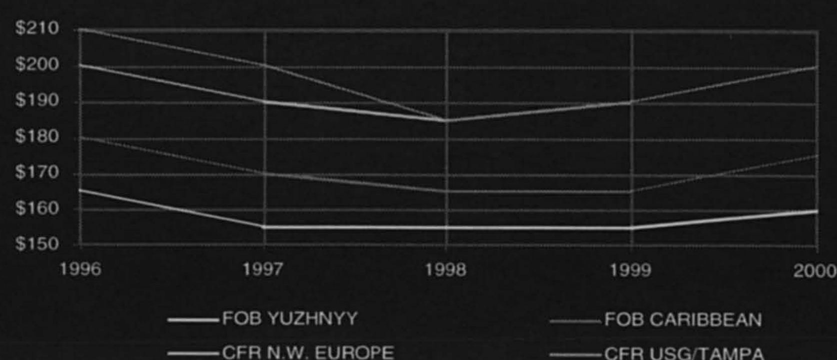
Terra Nitrogen

AMMONIA PRICE PROJECTIONS

($/tonne)

1996 - 2000

Source: Fertecon



Terra Nitrogen

Today's UAN Nitrogen Environment

- UAN Inventories Comfortable - Tight
- Imports Down from 1994 / 1995
- Late Season (June 95) Demand
- Excellent Fall 1995 Movement to Secondary Storage

Terra NITROGEN

What Caused This Current Situation ?

- Imports Down Due to Improved Western European Markets
- Dealers Positioning Storage for Expected Acreage Increase
- Secondary UAN Market Vigorous

Terra NITROGEN

What Are The Effects ?

- Firm Fall Pricing
- Spring Price Growth

UAN AVERAGE PRICES
FOB Mid-West Corn Belt
1988 - Sep 1995
Source: Green Markets

Future ?

- Prices will Continue to Remain Firm
- Spring Prices will Increase
- UAN vs Ammonia
- New Production

Terra NITROGEN

Today's Urea Nitrogen Environment

- U.S. Inventories Down
- World Inventories Down
- Imports Non-Existent Short Term
- Fall 1995 U.S. Demand Starting to Take Place
- Higher Prices

Terra NITROGEN

What Caused This Current Situation ?

Strong China and India Demand

Excellent Central and South American Demand

Unexpected Supply Problems in Indonesia

Temporary ban in Bangladesh & Egyptian Exports

FSU / Ukraine Gas Costs

Terra Nitrogen

What Are The Effects ?

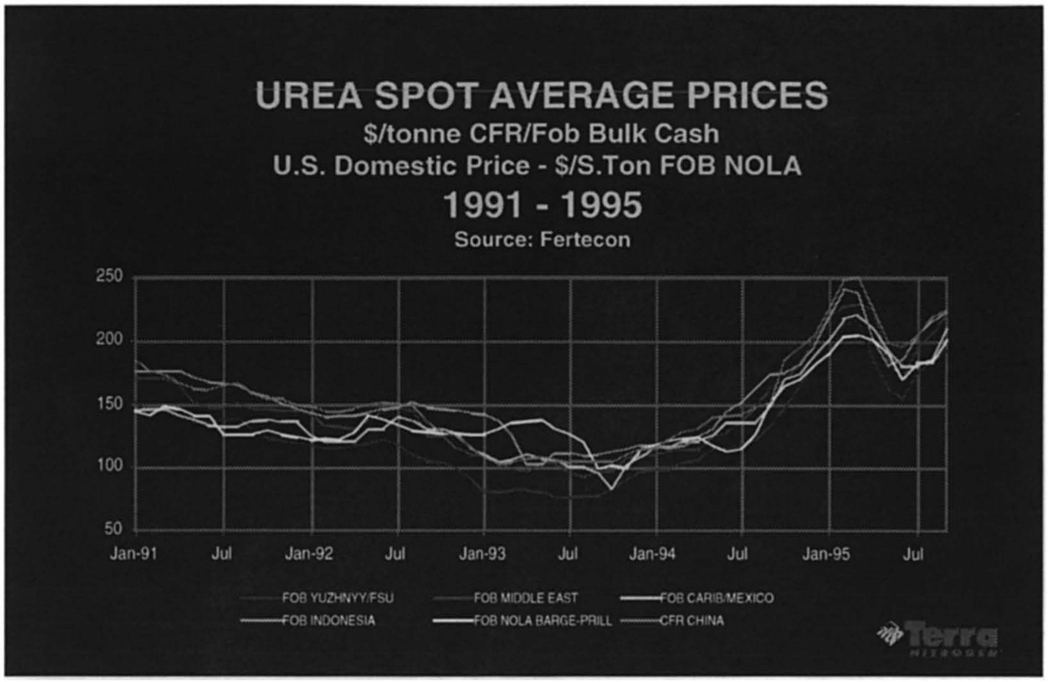
Higher World Prices

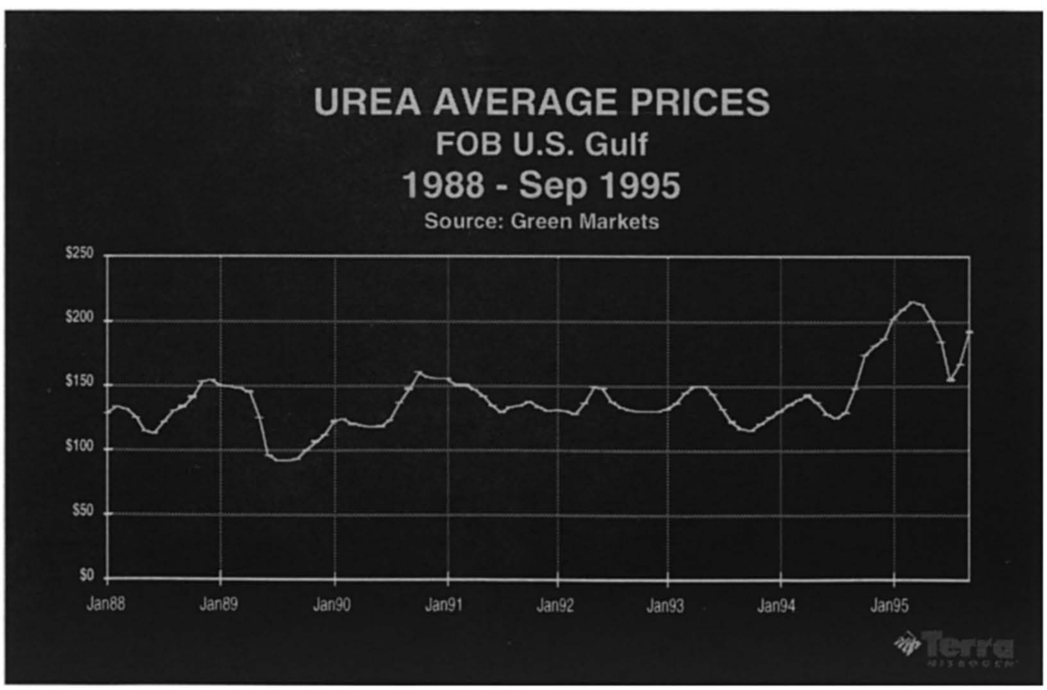
Higher FOB Gulf Prices

Higher Import Prices

Less Supply vs Demand

Terra Nitrogen


UREA SPOT AVERAGE PRICES
$/tonne CFR/Fob Bulk Cash
U.S. Domestic Price - $/S.Ton FOB NOLA
1991 - 1995
Source: Fertecon
250
200
150
100
50
Jan-91
Jul
Jan-92
Jul
Jan-93
Jul
Jan-94
Jul
Jan-95
Jul
FOB YUZHNYY/FSU
FOB MIDDLE EAST
FOB CARIB/MEXICO
FOB INDONESIA
FOB NOLA BARGE-PRILL
CFR CHINA
Terra


UREA AVERAGE PRICES
FOB U.S. Gulf
1988 - Sep 1995
Source: Green Markets
$250
$200
$150
$100
$50
$0
Jan88
Jan89
Jan90
Jan91
Jan92
Jan93
Jan94
Jan95
Terra

Future ?

- Long Term will Remain Strong through 2000
- New Urea Capacity

SUMMARY

- STABILILTY IN MANUFACTURING
- NEW AMMONIA PRODUCTION
- WORLD FERTILIZER DEMAND CHINA/INDIA
- WORLD FOOD DEMAND
- HIGHER FERTILIZER PRICES / SUPPLY DEMAND

Outlook For Phosphates and Sulfur

James A. Beck
IMC Fertilizer, Inc.

Good morning! I'd like to start by expressing my appreciation to the Fertilizer Industry Round Table for inviting IMC Global to speak to you today about phosphate and sulphur. I will review some of the major developments in world phosphate supply, demand and trade, look at the domestic industry and then examine projections of longer-term phosphate supply and demand. Finally, I will discuss the changing supply situation in the world sulphur business and the longer-term supply/demand outlook.

Since about 70 percent of the commercial phosphate used around the world is applied to grain crops, grain prices and area planted are key factors influencing demand. I'd like to start with an overview of the grains situation and outlook.

World grain demand continues to grow steadily at about 85 to 90 million tons per year. Production on the other hand fluctuates with weather and with government agricultural policies, especially in the United States. In four out of the last five years, grain consumption has exceeded production.

At the end of the 95/96 marketing year, world grain stocks are expected to equal only 14 percent of annual use. In total, grain stocks are about 40 million tons below the 16 percent of use level that is considered to be a "minimum" stocks level. Most of the decline in stocks since 1993 has been outside of the United States. The decline in grain stocks expected in 95/96 in the United States leaves the world with the lowest stocks level in over 20 years.

Let's take a closer look at corn stocks in the United States. The target range for ending stocks represents normal inventory levels. When stocks are outside of this range, growers tend to adjust production and planted acreage to bring stocks back towards the target ranges. The latest estimates by USDA place ending stocks in the 95/96 marketing year below 700 million bushels. Because of the stocks situation, corn prices are well above $3 today. Last year at this time corn prices were about $2.20 per bushel.

High corn prices and a zero acreage Reduction Program is expected to boost 1996 planted corn acreage to at least 80 million acres. Altogether, planted area is expected to increase about five million acres next year resulting in an increase in crop nutrient use of at least five percent.

Let's look at some of the dynamics of crop nutrient consumption.

Between 1970 and 1990, the growth trend in world crop nutrient use was relatively steady and predictable. Consumption increased 80 million tons, an average of four million tons per year. Since 1990, consumption has fallen 25 million tons or nearly 20 percent.

The reason for the decline, of course, was the dramatic drop in crop nutrient use in the Former Soviet Union and Central Europe due to the political and economic turmoil in those areas. Crop nutrient use has declined 30 million tons, equivalent to the amount of crop nutrient used in both North America and South America. The free fall appears to be over. Based upon current indications, we believe that consumption in the Former Soviet Union and Central Europe should increase 10 percent in 95/96.

Crop nutrient use in other developed countries has remained fairly stable. Growth in the United States has nearly offset lower consumption in Europe.

In the developing countries there has been steady growth.

Over the past 10 years, consumption in China has increased about 55 percent while consumption in other developing countries has grown about 40 percent. In total, crop nutrient consumption has increased 19 million tons in the developing countries over the past 10 years.

China is now the world's leading consumer of phosphate crop nutrients. Latest estimates indicate that China now consumes about 70 percent more phosphate crop nutrient than does the United States. The top three consumers, China, the United States and India, account for one-half of world phosphate demand.

Many people believe China imports nearly all of their phosphate needs. This is not true. In fact, China imports only 1/3 of their phosphate demand and with the balance being primarily low grade single super and magnesium phosphates produced at numerous small plants located throughout the country.

India is the world's second larger importer of $P_2 0_5$. Typically 2/3 or more of India's imports are in the form of phosphoric acid.

Over the past 10 years we have seen substantial growth in import demand in Europe. This is not because of growth in phosphate consumption. Rather, it is the result of the shutdown of most of the production capacity for concentrated phosphates in Europe. Imports now supply the production shortfall.

Because of the decline in production in the Former Soviet Union, world phosphate production in 1994 was 15 percent lower than 10 years earlier. Except for the United States, Morocco and Tunisia, which collectively account for 61 percent of world exports, all other major producing countries are oriented toward production for domestic consumption.

Phosphoric acid based fertilizer materials account for about 70 percent of world $P_2 0_5$ production. DAP is the leading product account for about 1/3 of total world phosphate nutrient production. Interestingly, single super, which accounts for less than one percent of US $P_2 0_5$ production accounts for 27 percent of total production outside of the United States. On a world basis, single super accounts for 19 percent of world production.

Of the 14.9 million tons $P_2 0_5$ in world trade, nearly 40 percent is DAP. Phosphoric acid, accounting for 1/4, is the second largest product. We expect DAP, MAP and phosphoric acid to account for virtually all of the growth in world trade for the foreseeable future.

During the past 10 years, concentrated phosphates exports have increased by 28 percent or 3.2 million tons P205. The United States commands a 38 percent share of world trade.

The United States is the clear leader in DAP exports accounting for about 2/3 of total trade. Morocco is the leading exporter of phosphoric acid with their primary market being India. With the collapse in demand in the Former Soviet Union, a significant amount of MAP has entered the world market from this major producing area.

The strong growth trend in US DAP exports was interrupted in 92/93 by a 50 percent drop in exports to China. Exports have recovered since then but still fall short of the 91/92 peak tonnage. Last year, China accounted for about 60 percent of US DAP exports.

IMC-Agrico is the leading producer of phosphoric acid in the United States accounting for about 1/3 of total capacity. Cargill is the second largest producer with 1.6 million tons of capacity. However, with the conclusion of the PCS acquisition of Oxy's phosphate facilities in North Florida, PCS Phosphates will become the second largest US producer with capacity nearly 2/3 that of IMC Agrico.

According to IFA estimates released at the recent meetings in Singapore, unused world capacity currently totals about 1.8 million tons $P_2 0_5$. However, much of this unused capacity is in small, high-cost plants that are not suitably located to supply the world market. Over the next five years, world demand is expected to grow more rapidly than world capacity resulting in a decline in the unused capacity. As a result, world supplies of phosphates are expected to continue to tighten.

By 1994, phosphate rock exports had fallen to 29 million tons. This is a drop of 19 million tons from the level of exports in 1984. Reduced exports from Morocco, the United States and the Former Soviet Union account for most of the drop.

Over the next few years, we expect some recovery in world rock exports as consumption recovery occurs in Eastern Europe. However, most of the decline in rock export has been permanently replaced by increasing trade in phosphoric acid or DAP.

World production of rock in 1994 totaled 129 million tons, 15 percent below 1984 levels. The increase in consumption of phosphate rock for conversion to concentrated phosphates for export has been more than offset by the drop in rock trade.

Let's look at the world sulphur market. Sulphur values are produced in a number of ways.

The most important source is sulphur produced in the elemental form. Over 80 percent of the world's elemental sulphur production is involuntary or recovered from sour crude oil and natural gas. Recovered sulphur production from natural gas accounts for about 45 percent of elemental sulphur production, however sulphur recovery from refinery streams is the most rapidly growing segment of recovered sulphur production.

IMC Global, in conjunction with Freeport McMoRan, operates the world's largest Frasch mine - Main Pass 299 in the Gulf offshore Louisiana. This mine accounts for about 1/3 of world Frasch production.

The United States is the world's leading elemental sulphur producer because of our use of large amounts of sour crude oil and our production of sour natural gas. Canada, the number two producer, is the world's leading producer of sulphur from sour gas. Most of the Canadian production is in the province of Alberta.

With increasing recovered sulphur production from natural gas and from refineries, many countries have emerged as important commercial suppliers of sulphur to world markets.

Over the next decade, Canada will continue to be the leading producer from sour natural gas; the Former Soviet Union is developing large sour gas reserves and will increase in importance; and Iraq will emerge as a leading sulphur producer when trade sanctions are lifted.

Because of our world leadership position in concentrated phosphate production, the United States accounts for about 1/3 of elemental sulphur consumption. In fact, the leading five sulphur consuming countries are also major producers of concentrated phosphate fertilizers.

Let's look more closely at the sulphur production in the United States.

Although the United States is the world's leading producer of Frasch sulphur, Frasch accounts for only 1/4 of current US sulphur production. About 1/2 of US production is recovered from sour crude oil refining. The balance of recovered sulphur production is from sour gas wells in the Gulf Coast area and in the Western United States. Future production increases will be mostly refinery recovered sulphur.

In the United States, 2/3 of our sulphuric acid consumption is used to produce concentrated phosphate fertilizers.

The non-fertilizer uses are primarily in chemicals and metals production processes.

With Main Pass reaching full production potential in early 1994, US sulphur production has been steady at about 850,000 tons per month. Demand has been strong and in most months, shipments equaled or exceeded production.

Production and shipments during the past 18 months from western Canada accurately reflect the changes in the world sulphur situation.

Early in 1994, world sulphur prices were so low that over one-half of western Canada's sulphur production was being poured to block rather than shipped to the market. As prices increased during the year, western Canadian producers cut back on inventory additions and increased shipments. During 1995, 90 percent of western Canadian production has been shipped with only modest tonnage going to inventory. Since the first of 1994, sulphur prices have increased about $30 per ton. This represents a $12 per ton increase in costs to DAP producers.

1991 was the last year of a decade of sulphur inventory withdrawal. In the early 1980's, sulphur stocks just in Western Canada reached 20 million tons. Ten years later, stocks had been reduced to only two million tons. The combination of increasing demand resulting from higher phosphate production and increasing supplies of sulphur from involuntary production sources have resulted in world sulphur output in excess of demand. This situation is expected to continue for the foreseeable future.

I appreciate the opportunity to appear on your program today and I would be pleased to try to answer any questions you might have.

Outlook For Potash

Ken Nyiri
MS Chemical Corporation

At last it's time to turn our attention to the Potash Outlook. As the clean up hitter for this session, my work is made easier since the speakers before me have given you all the important background information.

You already know about the weather. A wet spring in 1995 was followed by the long, hot, dry summer of 1995. As a result of these extremes in moisture, ending grain stocks in the United States and worldwide are at their lowest level since the early 1970's.

You also know that the government , reacting to this low grain carryover, will reduce the Acreage Reduction Program (ARP) for corn to zero allowing the U.S. farmer to plant more than 80 million acres of corn. Fence-row to fence-row is the operative phase being used by the industry. As a result, U.S. fertilizer consumption is expected to increase 6%-8% in 1995/96.

You also have heard that the international fertilizer markets are literally on fire. China and India are the two largest destinations for exported fertilizers—both are buying heavily keeping the export fires burning.

You already know that U.S. and World fertilizer operating rates (excluding the Former Soviet Union) are high and the worldwide fertilizer supply and demand balance is tight.

You have heard all these factors from our previous group of very capable speakers and I can tell you that as far as this potash industry speaker is concerned, I agree with every one of these points. So there is no need for me to review this information with you once again.

Instead, I thought I would take a few minutes of your time to give you an overview of the potash marketplace through the eyes of a U.S. (Carlsbad) potash producer. I'll follow this overview with a forecast.

U.S. Production

The world potash industry is highly concentrated with relatively few sources of supply. There are just twelve countries that produce potash worldwide; the three largest, Canada, the Former Soviet Union and Germany account for 72% of world output. The United States is a relatively small world potash producer.

U.S. potash production peaked in the mid - 1960's at 3.3 million short tons K2O and a 21% share of world output. U.S. potash output and market share have decreased ever since. Last year, the U.S. produced half as much potash, 1.6 million short tons K2O, representing a 6% share of world output.

Potash production in the United States has been declining for a number of reasons. Declining ore reserves, lower ore grade and failure to replace depleted mines are among the more important reasons. Certainly, the huge investment in potash mining in Canada lessened the incentive to replace depleted U.S. mining capacity, and the U.S. market became more and more dependent on imports from Canada.

Currently, U.S. potash is produced from ten mines located in four states. New Mexico's five Carlsbad mines account for about 80% of U.S. output. Three mines produce potash in Utah, one in California and one in Michigan.

Industry Dominated by World Trade

More than any of the other fertilizer nutrients, the potash industry is dominated by world trade. In 1994, 82% of all potash production was shipped outside the country it was produced. Eight of the twelve producing countries export more than half of their total potash output. Three countries, Canada, Jordan and Israel export virtually all of their production. These countries have very small domestic potash markets and rely almost solely on the export markets to sell potash and keep their mine running.

The United States is, by far, the largest consumer of potash and the largest potash imported. The U.S. represents more than one-fourth of world consumption and one-fourth of world trade. But the United States is not a major exporter, exporting about a half a million tons or about 2% of the world's 20 million ton international trade in calendar year 1994.

While you may read a lot in the industry press about the potash markets in China, Brazil and India, these next three largest potash importers combined just barely stack up to the total potash imports into the U.S. market. By far, the Canadians are the largest suppliers into the U.S. potash market accounting for 5.0 million tons in calendar year 1994. Five other countries: France, Germany, Israel, Jordan and the FSU also export to the states. Combine these five accounted for less than 400,000 tons of K2O in 1994.

A Shrinking U.S. Market

After peaking in fertilizer year 1980/81 at about 6.4 million tons K2O, U.S. potash consumption fell sharply in the early 1980's and has been hovering around the five million ton levels for the last ten years. Most U.S. potash consumption is on row crops-corn and beans are the two largest. Planted acreage of these crops has not changed significantly since the peak in potash consumption, U.S. farmers are just applying less. On corn, for instance, application rates fell from about 85 lbs. per acre in the early 1980's to just 80 lbs. per acre in 1993/94. Despite this decline in potash applied, corn yield increased from about 110 bushels per acre in the early 1980's to about 128 bushels in 1993/94. This represents a 16% or 18 bushels per acre increase.

Indeed, there are a number of reasons for these reduced rates. As with all inputs, the farmer has learned to use potash more efficiently. The farmer is feeding the plant rather than feeding the soil. Some may argue that the U.S. farmer may also be mining the soil reserve of its potash-potash that was built from years of excess application. That is the subject of another paper. For our purpose, it appears that U.S. application rates of potash may have leveled out and are even showing signs of an upward trend.

A Shrinking U.S. Share

A look at a few maps will help us understand the potash fertilizer markets and the dominate players in each market. As you might expect, potash is a commodity, sold on a delivered costs basis. Certainly some other issues come into play such as quality and reliability, but most important is the delivered costs.

The first map shows where potash is shipped into the U.S. To no one's surprise, the mid-west corn belt states consume most of the potash. According to the railroads, a point equal distance from both Carlsbad and Saskatoon is about Chicago, the center of potash consumption in the United States. This represents about 1,300 railroad miles from both mining locations.

However, we all know that since deregulation, transportation rates are negotiated and distance, while still very important, is just one factor defining a rate. When you shipped 5 million tons of K2O (over 8 million tons of product) into the U.S. marketplace, as the Canadians do, you get the attention of the railroads real fast.

Minimizing distribution costs are critical to survival, both short term and long term. This is particularly true for the much smaller, higher costs U.S. potash manufacturer. With the world's largest potash market at home, in his own backyard, you would think he would have a competitive advantage. But the result show his sales and share are declining.

This chart shows U.S. muriate potash sales from U.S. producers over the last ten years. U.S. potash sales increased from about 400,000 tons K2O in 1985/86 to a peak of 800,000 tons in 1989/90. Since 1989/90, the U.S. potash sales to the home market have declined.

A look at market share shows a similar pattern. Market shares increase, peak, then decline.

The Backyard Market

The North American and worldwide potash markets are very competitive. Producers are constantly jockeying tonnage back and forth to improve market shares and net-backs. It's the nature of the business. The old adage, give them an inch and they will take a mile is certainly true in the potash market, particularly since so much of the tonnage must move a considerable distance to market.

As you can see when we plot the market shares for U.S. producers, in general, the further the distance away from Carlsbad, the lower the market shares and the lower the sales volume. It's not some kind of mystery, it 's simple distribution economics. Your delivered costs increase the further you move away from the source. There's no collusion. There's no allocation of markets. It's simply delivered costs.

The Canadians along with most of the other potash manufacturers, must export to survive. The domestic Canadian potash market is just 400 thousand tons K2O, certainly not large enough to support 13 million tons of mining capacity. Canadian mines are operating at about 76% of capacity or about 10 million tons of K2O output. At this level, the Canadians held over 3 million short tons of excess potash capacity off the market.

The next map shows the sales of Canadian potash into the U.S. As you can see here, in general, the pattern of distribution costs works in most cases. However, Canadian potash sales have penetrated deep into some areas, areas where Carlsbad producers enjoy a significant distribution cost advantage.

The Canadian producers are currently accepting very low net-backs on potash sales into U.S. markets, particularly into the natural Carlsbad backyard market where higher freight and distribution costs are incurred.

One Canadian potash company is even considering opening a distribution point at Elkhart, Texas — that's between Waco and Tyler. Elkhart is about 650 rail miles from Carlsbad and 2,600 rail miles away from Saskatoon. The Carlsbad potash producer certainly enjoys a significant freight advantage into Texas — its their largest market.

Several U.S. potash mines have considerable reserves remaining. These reserves can, for the most part, be mined with little or no capital investment. Carlsbad potash can and should be competitive in its own backyard market.

North American Potash Capacity

I could sum up the potash outlook very quickly, but before I do, let's take a look at a few more slides. This next slide shows the dominance of the largest North American supplier in terms of total capacity. PCS represents an estimated 47% of North American potash capacity. However, according to their published numbers, PCS operated at only 4.2 million tons K2O in fiscal year 1995 or about 60% of their rated capacity. As a result, PCS production accounted for only a third of the 11.6 million tons of North American outlook. This suggests that the rest of the Canadian industry operated at over 95% of capacity and the U.S. industry operated at under 90%. As I said earlier, there is some spare capacity available in the market.

The Potash Outlook

The driving force behind the improvement in the potash supply/demand balance has been the international market. In the international market, after a 28% (1 million ton K2O) increase in exports last year, I expect a more modest increase in offshore sales for this year. Could it go higher? Certainly, but let us be conservative and hope for a pleasant surprise.

In the domestic market, on-farm potash consumption should be up as much as 8% in fertilizer year 1995/96. Nevertheless, domestic potash shipments may not recover as much since the dealer pipeline was full at the end of June. These stocks must be worked off before potash is reordered.

Overall, because the North American potash industry built stocks in fertilizer year 1994/95, the industry could hold potash production at last year's level, and still supply the increase in demand.

As always, there are no guarantees. At the current time, the bullish factors outweigh the bearish factors. Both domestic and international potash demand should improve somewhat this year and the supply/demand balance should remain relatively tight. However, on the bearish side, anything could, and often does happen. One of those uncontrollable bearish factors is the weather. As we saw in the spring of 1995 the weather is the most critical factor determining if the farmer plants, fertilizes, and eventually harvests his crops. If we could predict or control the weather better, we might be able to forecast fertilizer usage more accurately.

Logistics and Economics of Fertilizer Movement

Fernando Mugica
CF Industries

Logistics and economics are two terms that are used very frequently throughout the business community. For me, sometimes it is difficult to know what exactly is meant by these terms. In fact, this subject reminds me of a Yogi Berra story. During spring training on a beautiful day following a severe hot spell, a fan approached Yogi and commented:

" Good morning Mr. Berra, you look awfully cool today."

To which Yogi promptly replied:

" Why thank you, you don't look so hot yourself. "

You might be wondering what this story has to do with logistics or economics. The point of the story is that, if someone asks you to talk about the subject of logistics and economics in the fertilizer industry, you better be careful how you respond.

In my case, after agreeing to speak to you on the subject, I quickly determined that the topic, as stated, was much too broad and that I had to make some decisions as to how to narrow it down to a manageable size.

Possible Approaches to a Very Broad Subject

Our domestic marketplace is comprised of 2 million farms which consume some 21 million tons of nutrients throughout diverse geographic territories. These products are distributed through a vast network of dealers and wholesalers that utilize countless intermediate distribution and storage facilities and multiple transportation modes.

This complexity is increased further when one considers the global nature of our industry. Clearly world trade and events overseas have a direct and rapid effect upon our domestic marketplace. Certainly, it can be argued that the logistics and economics of fertilizer movement should be viewed in the context of this world market, thereby, vastly increasing the complexity of the subject matter.

In short, all kinds of possibilities exist when studying this topic. Should we look at global or domestic trade and shipping patterns? What fertilizer products do we look at? What movements are we interested in? What do we mean by economics—costs, margins, returns? What do we mean by logistics? After thinking about the variety of ways in which the subject could be approached, I realized that the discussion could be generally positioned somewhere along the following two dimensions:

The depth of the discussion from an analytical point of view, that is to say do we want to emphasize numerical data and then draw conclusions from the data? Or, alternatively, do we want to emphasize ideas and relationships without concerning ourselves too much with measurements?

The breath of the discussion—do we want to emphasize a specific part of the industry (farmer, dealer, wholesaler, producer) or do we talk conceptually about the fertilizer industry or, possibly, any industry?

After considering various factors unique to our situation today, I concluded that from a "Breadth" standpoint, it would be best to think about logistics from the perspective of a unit which would be no smaller than a fertilizer producer. From a "depth" standpoint, I concluded that I should use as few facts and figures as possible and that talking about ideas would be more interesting.

I would like to organize the discussion in two parts. The first part will look at logistics performance as measured in the traditional sense of distribution and storage costs, with some data drawn from recent CF Industries experience.

The second part will deal more conceptually with recent thinking about the process of logistics and will discuss some ideas that are more generic. For this second part of the discussion, one could restate the topic as:

"The Logistics Process and Its Importance to Fertilizer Producers"

What do we really mean by the term logistics? In a recent article, US News and World Report says that logistics is "the science of moving materials throughout the country." While logistics is, in fact, generally associated with the shipping and transportation functions, for our industry it is typically also thought as typically encompassing inventory management and product storage considerations. Using this traditional definition of logistics, I would like to review some recent CF experience.

Recent CFI Distribution and Storage Performance

In 1994, CF spent well over $100 million in distribution and storage expenses. As figure 1 shows, growth in distribution and storage costs has been more than accounted for by growth in sales. Although distribution and storage outlays in aggregate have risen approximately 21 % since 1990, sales have increased by almost 41% during that same time. The net effect has been that distribution and storage expense per ton of product sold has actually declined over the past several years (See Figure 2):

As is often the problem with income statement data of this type, it can tend to lead one to incorrect conclusions. In this case, we have two general problems:

1. The data does not properly reflect the capital required to maintain improve, and safely operate the distribution and storage system.

2. The data covers a period of exceptional volume growth which may be nonrecurring.

Specifically for CFI, these data do not serve as a good indication of the recent trends that we are seeing with respect to logistical (distribution and storage) costs. The results have to be viewed within the context of the following factors:

- The general improvement in the health of the fertilizer market during the last five years has resulted in increased sales. These increased volumes enabled CF to fully utilize its captive distribution and storage infrastructure, improving utilization and lowering unit costs.

- During this time, CF divested itself of inefficient transportation assets while investing in new facilities which reduced its transportation costs. These actions also helped to drive down unit costs.

- During this time, CF invested several millions on distribution and storage capital projects which are not included as operating expenses on the income statement. Even after adjusting for non-cash expenses, the figures tend to understate the true cash outlays over this time periods as these capital costs are significant, essential expenditures necessary to properly operate the infrastructure.

The costs are also understated in that they do not recognize the cost of carrying inventory. These costs can be significant given the extreme seasonality of our business.

Bladders and Elephant Rings

Thus, we believe that these broad aggregate measures of distribution and storage costs recently experienced in fact mask some powerful underlying forces that will significantly push up the prices that producers will pay for transportation and storage capacity in the future.

For example, right now there are a number of states which have regulations on the books requiring companies that store liquid chemical products to provide secondary containment systems for their storage tanks in order to safeguard against tank failures. At CF, we are looking at systems called Bladders" (tank liners) and "elephant rings" (steel containment structure) to help us comply with these regulations. Depending upon the size and configuration of the tank, these systems could cost as much as $500 thousand per installation.

Not only are compliance costs such as these likely to escalate, but we also believe that providers of transportation and storage services, who are facing many of the same pressures, will attempt to pass on some of these increases in the form of higher rates for their services. To summarize, we believe there will be significant upward cost pressure on distribution and storage costs because of:

- Increased regulations for secondary containment and other legislative actions at the state or federal levels affecting providers of chemical storage and transportation capacity.
- Increasing competition for relatively scarce rail and barge transportation equipment.
- Ongoing consolidation in the transportation industry while demand is increasing.
- Increasing trend in Washington to raise revenues via user fees.

Will Consumers Pay These Higher Prices?

Moreover, it is clear that fertilizer producers can not rely upon the marketplace to help them recover their costs of distributing and storing products. Market prices in our industry are characterized by great volatility, are determined by a variety of factors, and may not be enough to offset costs, much less provide a return on investment. Although over the long term one would expect that the marketplace must recognize these costs, the history over the past several years would indicate otherwise. As an example of two of our major products, ammonia and DAP, Figures 3 and 4 show the relationship between market pricing at the respective production points and a reasonable guess of a typical producer's costs to deliver those products into the marketplace.

The Logistics Process—Should It Do More?

These conditions will require that producers continue to pay close attention to the distribution and storage component of their total costs. Traditionally, the term "logistics" has meant exactly that, those activities concerned with shipping, storage, and controlling the accompanying costs. Recently, however, the term "logistics" has taken on a broader meaning in many companies. I would like to refer to this broader concept of logistics as a "logistics process", which today has taken on additional importance as a tool to improve customer satisfaction. In fact, customer satisfaction surveys have, for some companies, now become another measurement of logistics effectiveness, complementing traditional transportation cost measures. Some of these new ideas may also be applicable to our business, but first they should be placed in the context of a revolution that has been taking place in business for quite some time now.

These "new" ideas have in fact gained momentum in the last ten years or so. During this time, companies in all industries have been forced to reexamine the way they do business. These are some of the forces which have caused this analysis:

- Customers demanding better products and services.
- A shift in the "ownership" of time from sellers to buyers.
- Increasingly competitive, global marketplace.
- Deregulation and consolidation of transportation industry.
- An explosion in technological advancements.

These and other factors have led to a total reassessment of the fundamental purpose of a business enterprise. Traditionally, the purpose of a business used to be described as:

To maximize shareholders wealth over the long run.

This focus on the owners of a company is generally thought to be inappropriate given today's business realities. Instead, companies are focusing much more on the customer and making their underlying mission statement more like:

To supply products and services which create value for all the customers.

This emphasis on the customer and his needs was first reflected in an emphasis in improving product quality. Today, product quality is a basic requirement to compete in the marketplace. In order to create value and achieve differentiation, companies have had to adopt a total customer satisfaction goal which, in essence, has meant a new emphasis on improving the quality of the services delivered to the customer. An effective logistics process is a critical component of any strategy aimed at improving service quality.

Moreover, this recent emphasis on service quality and customer satisfaction is not limited to noncommodity, consumer-oriented businesses. It appears that any industry that has customers is beginning to think this way. As an example in our own chemical industry, the trade magazine Chemical Week asked chemical manufacturers and carriers to rank various issues in order of importance. The results of the survey revealed that the most important issue for the respondents was customer satisfaction.

According to Chemical Week "In the past the better companies were sometimes evaluated on their ability to solve problems; in the future the emphasis will be on the avoidance of problems altogether."

It is clear that today, customer satisfaction is a major issue throughout the business community. I would like to explore more deeply the elements of a logistics process and why it may be of particular importance to fertilizer producers interested in implementing a customer satisfaction objective.

The Logistics Process

Recently, the Wall Street Journal's front page ran a very interesting article which ties in to this discussion, its title:

Driving Force—In Today's Economy, There is Big Money To Be Made in Logistics

Although the article paid particular attention to the trucking industry and computerized systems now being employed, the following aspects of the logistics process still were evident:

Logistics is a discipline which ties together many functional areas and is not a functional area in itself. An effective logistics focus will involve many functions within the organization.

Logistics is long-term focused, whereas shipping/transportation efforts tend to address immediate or short term requirements of the enterprise.

The logistics process has as its goal the integration, over a long period of time, of the various functions of the enterprise, from raw materials procurement to invoicing of the customer, in a manner that is seamless and highly efficient. Its fundamental objective is to deliver maximum value to the customer at minimum cost to the enterprise. It can be called other things ("integrated supply chain Management" comes to mind), but I have tried to depict the concept in Figures 5 and 6.

In effect, the organization is implementing a logistics process when the components of the supply chain are full) integrated and committed to the ultimate goal of delivering the product to the customer and providing those services which are important to the customer. Companies that are at the forefront of logistics excellence structure rewards systems to achieve these objectives and construct appropriate measures of what constitutes logistics productivity. Moreover, traditional views of goal setting oftentimes focusing on functional accomplishments need to be oftentimes replaced with more "process" oriented goals and objectives.

Logistics Process is Important for Fertilizer Producers

I have tried thus far to describe the logistics process as a discipline which is not only concerned with helping an enterprise control its transportation and storage costs, but which can also be valuable for implementing service quality improvements. But it seems to me that a good logistics process can be of particular importance to a fertilizer producer because:

- The commodity nature of the product leaves few avenues for differentiation among competitors.

- The seasonality of the business coupled with the high Costs of maintaining a distribution and storage infrastructure makes the inventory management aspects of the business particularly crucial.
- The great volatility and lack of clear relationships between raw material costs and fertilizer prices make the supply chain management efforts particularly important.

- The great volatility and lack of clear relationships between prices in the market place and at the production point make the management of transportation and freight costs particularly critical.

- It helps to identify only those aspects of the business that truly are important to the customer.

- It helps to eliminate activities, expenditures, and facilities which do not add value to the customer.

It's not inconceivable to conclude, thus, that a responsive logistics process may be the only way that a fertilizer producer could effect a strategy of differentiation and customer satisfaction.

The Logistics Process at CF

I believe that most fertilizer producers have some form of the logistics process in place in their organizations. At CF, we use it primarily as a tool that helps us put structure around our supply and distribution systems. Cross-functional product supply teams work together (See Figure 7) to develop product supply plans which dictate the operations in detail of the supply and distribution systems. (See examples of CF s&d systems in Figures 8 & 9).

Clearly, we at CF are only now beginning to recognize the potential of an effective logistics process from the standpoint of delivering customer satisfaction. The integration of a logistics process across all levels of functions is only beginning. Instead, logistics is employed primarily in its traditional role of delivering sensible shipping instructions for operating a supply and distribution system over time.

Summary and Conclusion

I have tried to describe how traditional logistical dimensions of distribution and storage will continue to play a major role in a fertilizer producer's efforts to control costs. More broadly, however, the logistics discipline in today's business climate can be viewed as a process which not only incorporates traditional shipping considerations with considerations related to customer satisfaction and service quality objectives.

Also, logistics is of particular importance to a company which is at once pursuing a customer satisfaction strategy while using service quality as the differentiating factor I conclude that, in today's business climate and given the commodity nature of our fertilizer business, logistics effectiveness is virtually indispensable for fertilizer companies seeking to execute a customer satisfaction strategy .

In closing, I would like to say that it's unclear to me where the discipline of logistics will lead to in the future. However, it appears to me that the present business climate which has contributed to this fundamental change in the way in which businesses think is likely to be around for some time, and thus, I predict that the importance of the logistics process is more likely to increase than decrease.

In that regard, I would like to close with another Yogi Berra story regarding predictions. A reporter was pressing Yogi for his views as to how well the Yankees were going to do during the season, but to no avail. Exasperated the reporter asked Yogi:

Why won't you take a guess Yogi?

To which Yogi replied:

Because predictions are hard, especially when they're about the future.

I fully agree with Yogi. Thank you for your attention.

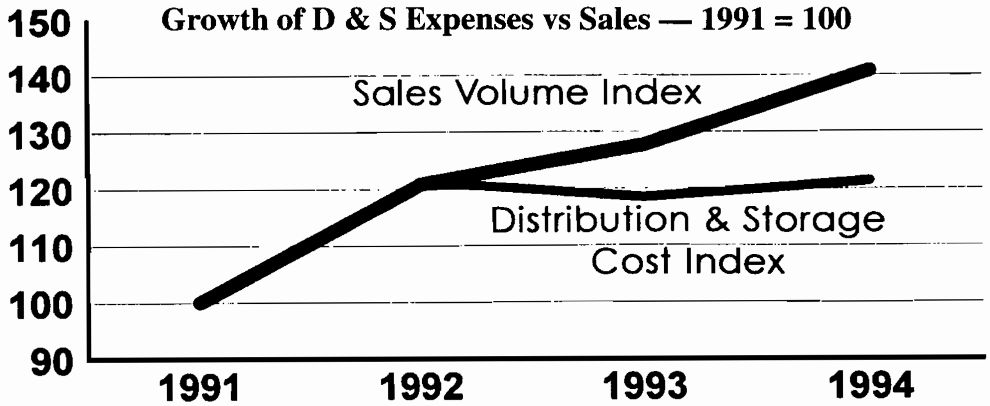


Figure 1. **Growth in Sales Volume Has Outpaced Growth in Distribution and Storage Costs for CF Industries.**

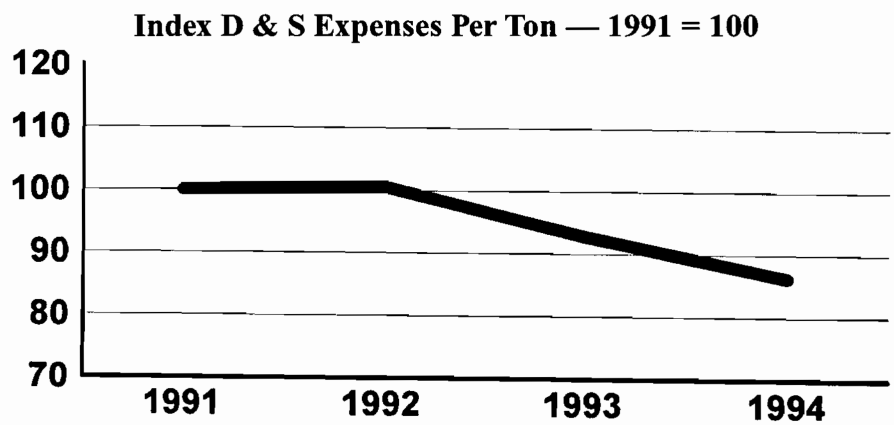


Figure 2. **Distribution and Storage Expenses Per Ton Have Actually Declined.**

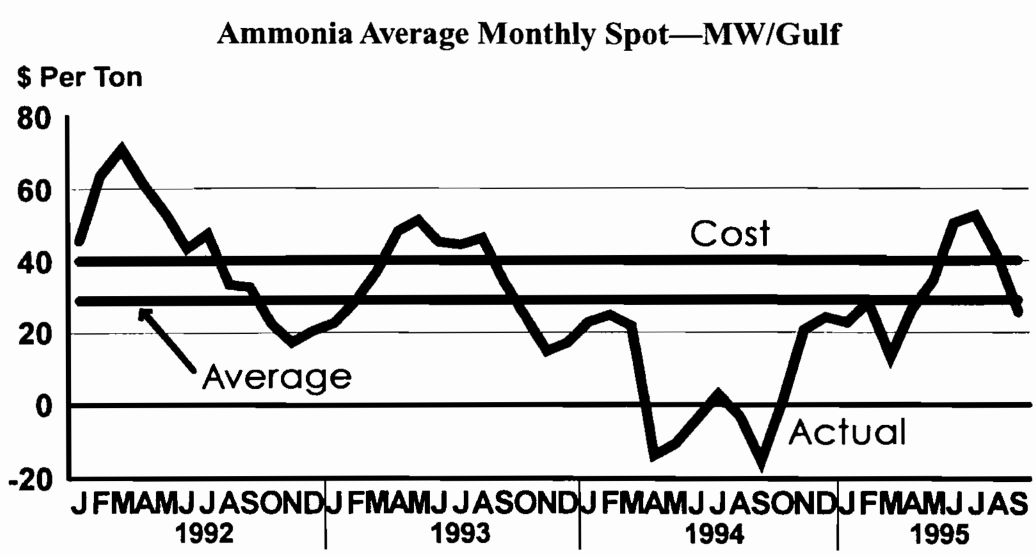


Figure 3.

DAP Average Monthly Spot—MW/Florida

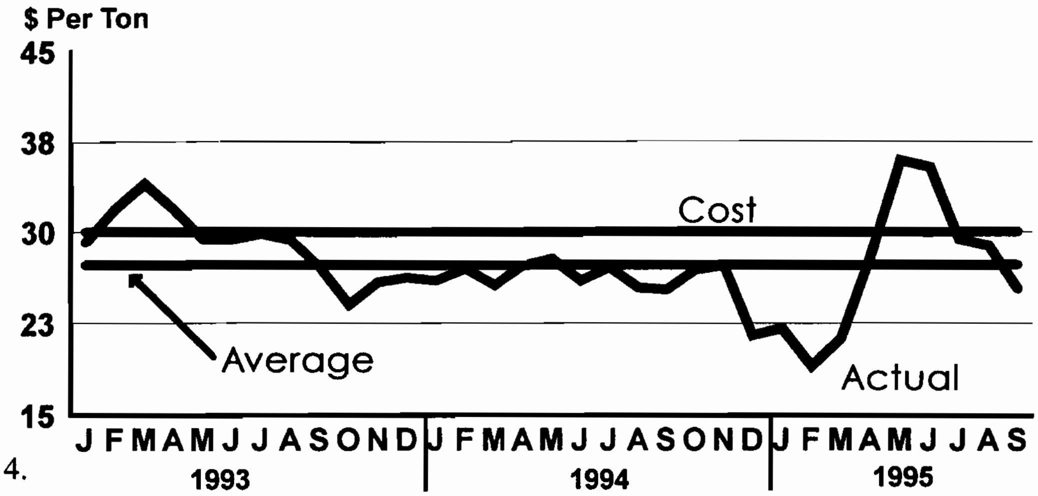


Figure 4.

Ammonia Average Monthly Spot—MW/Florida

Logistics & Economics of Fertilizer Movement

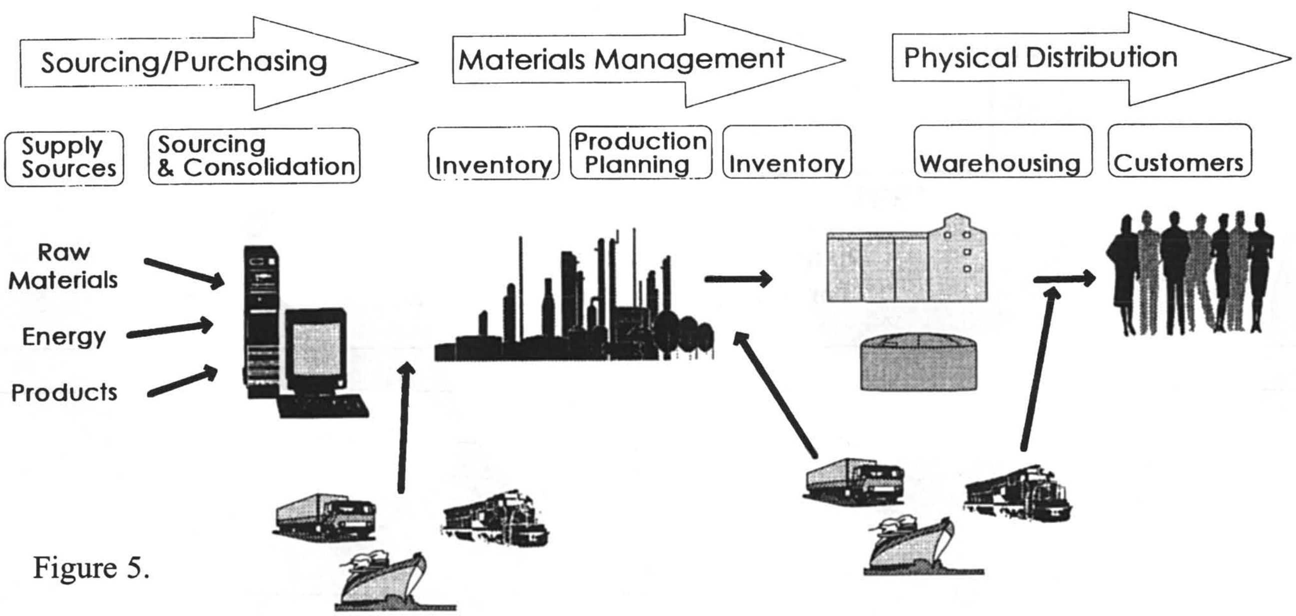


Figure 5.

The Logistics Process for Producers Starts at the Supplier Level and Ends With Delivery to the Customer.

Position Among the Logistics Process & its Functional Area

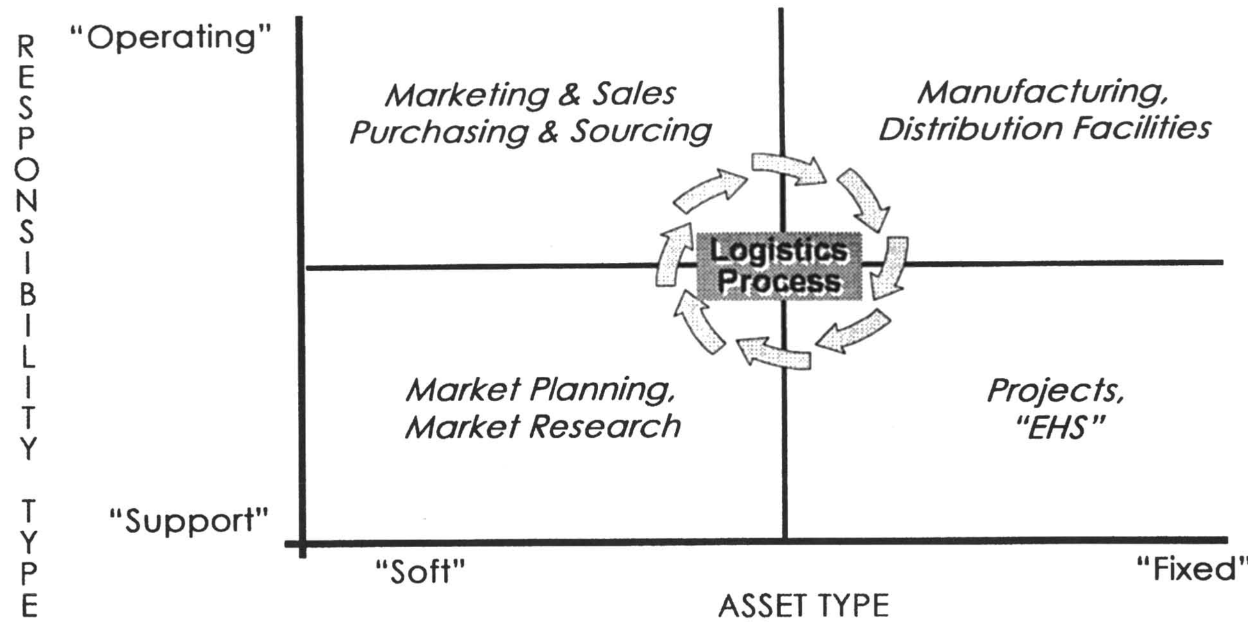


Figure 6. **The Logistics Process Ties Together the Various Functions of a Business.**

CFI Supply Planning Process

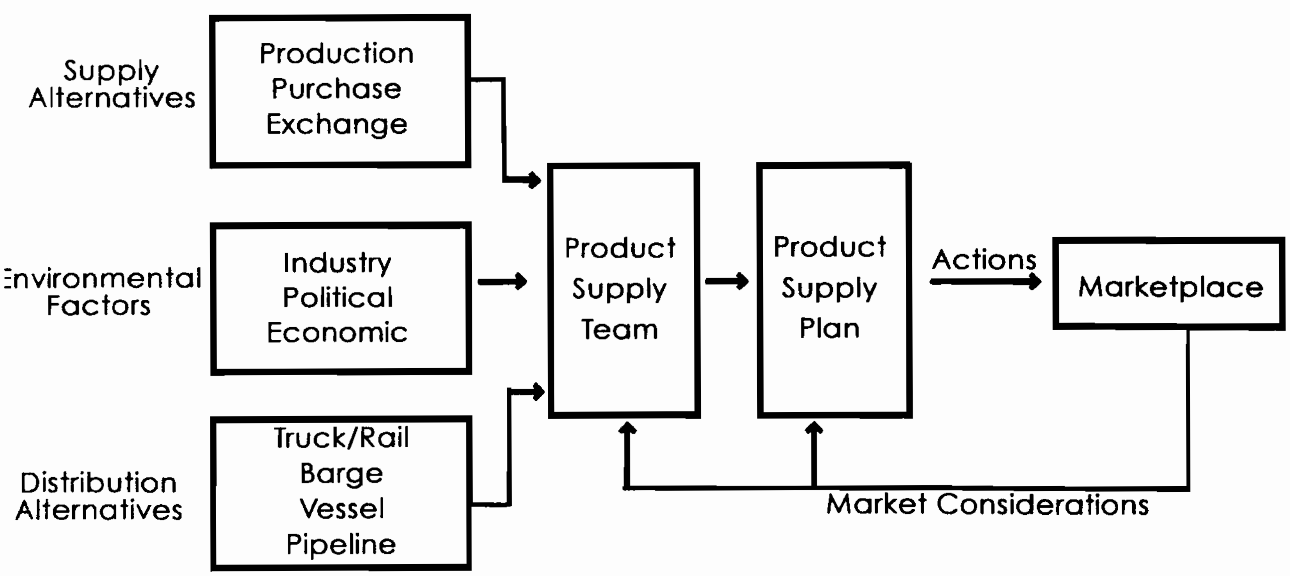


Figure 7.

Logistics & Economics of Fertilizer Movement—CF Ammonia System

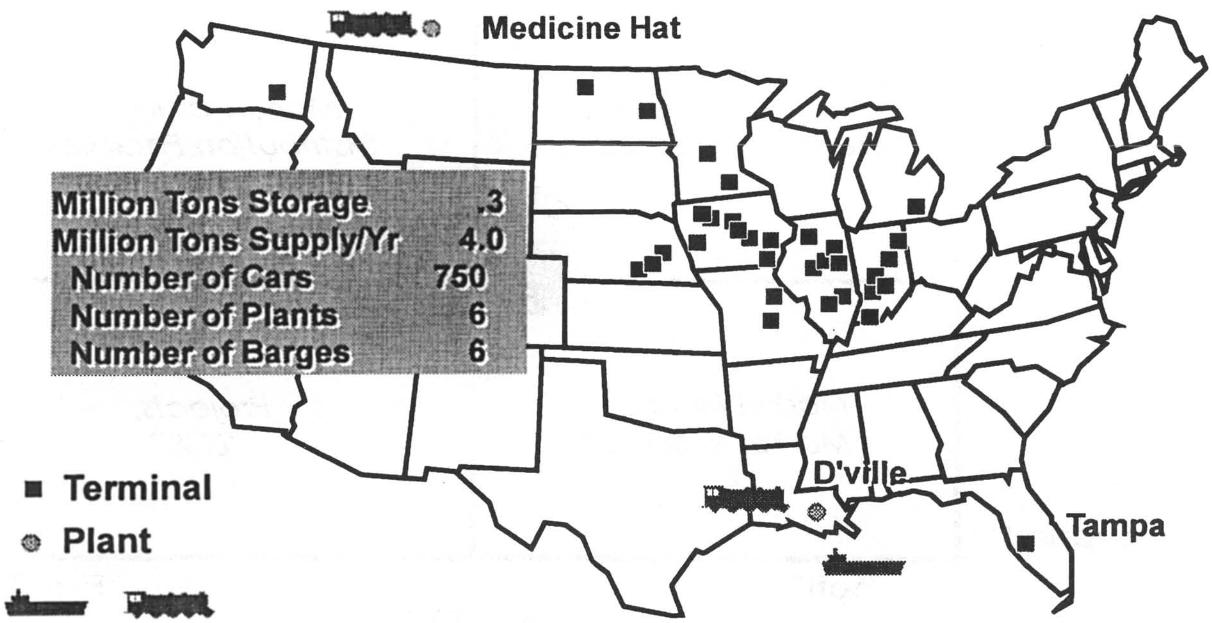


Figure 8.

Logistics & Economics of Fertilizer Movement—CF Phosphate System

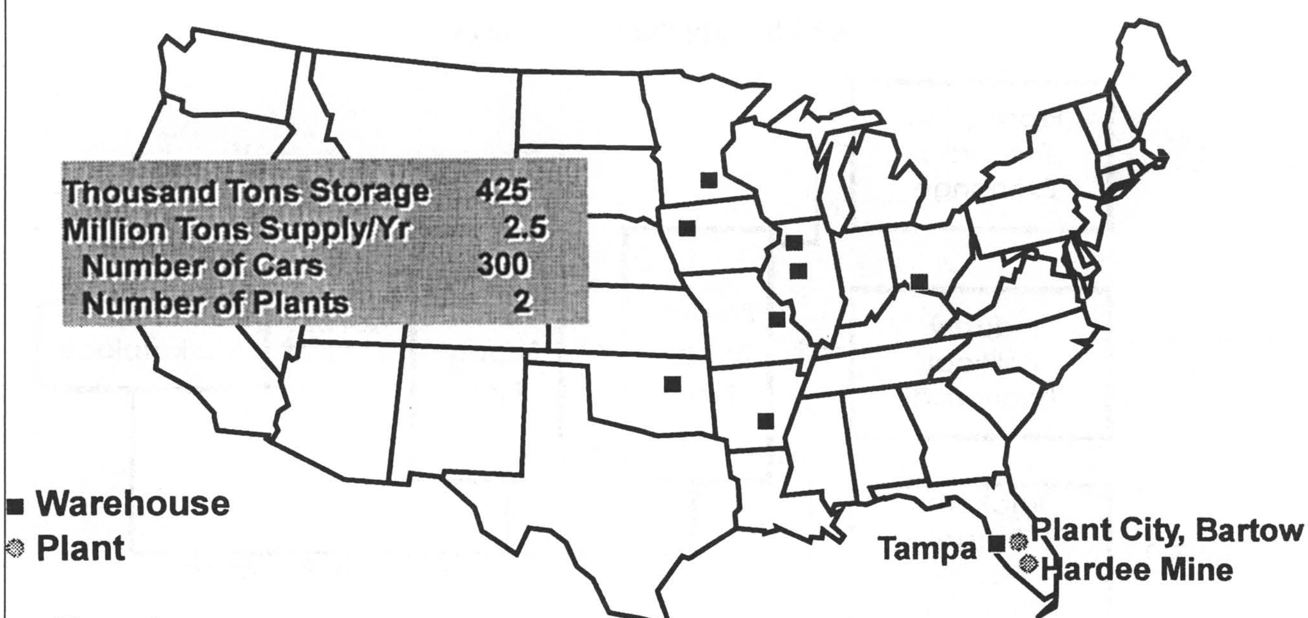


Figure 9.

Monday, October 23, 1995

Session II
Moderator:

Dale Dubberly

Changing Perception of Fertilizer World-Wide

Luc M. Maene
International Fertilizer Industry Association

Introduction

"He gave it for his opinion, that whoever could make two ears of corn or two blades of grass to grow upon a spot of ground when only one grew before, would deserve better of mankind, and more essential service to his country, than the whole race of politicians put together".

Jonathon Swift's words from Gulliver's Travels form the concluding statement to a recently published IFA document 'The Efficient Use of Plant Nutrients in Agriculture', written by Johnny Johnston of Rothamsted, England who was IFA's International Fertilizer Award Winner last year.

This quote encapsulates man's eternal quest for greater yield and efficiency in food production in a world with a rapidly growing population but limited resources, particularly land. Johnston's paper reviews the whole history of the development of agricultural systems, soil fertility, nutrient management including fertilizers, the environment and the importance of sustained research and extension programs.

Public concern has, however, been expressed over the use of fertilizers for a number of years. With increased awareness of the effects of human activity on the environment, modern agricultural technology has been scrutinized, and modified where required. To respond to this concern, our industry is devoting considerable effort to ensuring plant nutrients are optimised - applied, recycled and used efficiently to minimize losses.

Objections to the use of fertilizers are not based solely on the perception of fertilizers as a cause of pollution, soil impoverishment and degradation, reduced plant resistance to diseases and diminished quality of the produce. It is also felt that the easy availability of fertilizers has made possible practices that are regarded with distrust such as specialized farming and intensive agriculture.

The paradox of abundant food supplies in the rich, industrialized, developed world while more than half a billion people in poor, developing countries live with a food deficit, will become one of the 21st Century's greatest challenges. It is vital that our industry participates fully in the search for viable and sustainable agricultural systems, encouraging the use of fertilizers in integrated, productive, efficient, environment-friendly farming all over the world.

Lessons from History

It is worth reminding ourselves of the reasons why many ancient civilizations proved unsustainable—Johnston highlights two in particula—Mesopotamia and Mesoamerica. In Mesopotamia, the Sumerian society started around 3000BC and became dependent on extensive and complex irrigation systems to provide food for the expanding population. Its agricultural base declined as a combination of vulnerable soils and deteriorating water quality led to increasing salinization. Crop yields per hectare declined by 65% between 2400 and 1700BC.

In Mesoamerica, the Mayan society developed from around 2500BC, but population pressure pushed agriculture onto marginal land and by 800BC production was declining due to deposition and blocked drains following soil erosion caused by forest clearance on steep hillsides. These examples of the rise and fall of great civilizations because of salinization and deforestation illustrate also two of the major threats to the sustainability of agriculture in many parts of the world today.

In China, for thousands of years farmers practiced excellent management of cultivated land. As late as 1949, organic sources provided more than 98% of the nutrients applied to soil - now the proportion is less than 38%. The inevitable losses of nutrients from the soil-plant-animal cycle were compensated for by the transport of soil and plant residues from the uplands to the lowlands. Whilst this process undoubtedly helped feed China's increasing population, it is ultimately unsustainable. Also initially based on shifting cultivation, European agriculture required techniques of cereal-fallow and later cereal-legume-fallow rotations, practiced as early as Roman times, once the newly cleared woodland was no longer capable of giving acceptable yields.

Divorced from the Land

The development of fertilizer applications to augment the soil nutrient reserves is instructive reading in Johnston's paper. Prior to the Industrial Revolution, people mainly lived in rural communities, but as urban populations grew in the late 18th and early 19th centuries, the process began whereby large sections of society in successive generations became increasingly divorced from the daily realities of farming and food production. But the potato famine in Ireland, the dust bowls in the mid-West USA in the 1930s, and food shortages through two world wars continued to reinforce the importance attached to farming as an essential ingredient in Western society, both to politicians and the public at large.

Intensification of agricultural production had a remarkable impact - not just in terms of productivity, guaranteed supplies, greater variety, quality, surpluses and widespread trade in agricultural commodities - but also the perception among the urban public of farming as an indispensible reality began to change. Initially it was romanticized - the rural idyll - of green fields, grazing animals, bountiful crops and a simple, relaxed, healthy lifestyle. But as awareness grew of the environmental cost of man's activities, farmers in the West began to be viewed upon with suspicion and derision.

Attention was drawn in the 1970s and 80s to agricultural practices considered to be dangerous or insidious. These included animal husbandry systems perceived to be unnatural or degrading, landscape changes, loss of wildlife habitats, soil erosion and loss of soil fertility, pesticide residues in water and foodstuffs, nitrate in ground and surface waters, and eutrophication of surface water with nitrate and phosphate leading to algal blooms.

Growth in the popularity of 'organic' and 'natural' food coincided with a widespread negative perception of anything 'chemical', 'artificial', 'unnatural' or 'additive'. Surveys indicate that people typically do not differentiate between fertilizer and agrochemicals, for example - these are lumped into the same chemical category. It is in fact quite difficult to explain to a layman the difference between fertilizers and pesticides which are intended to be toxic to at least one class of organisms. It is also difficult to reassure sceptics that plants only take up nutrients as inorganic salts, irrespective of their source.

We in the international fertilizer community have become sensitive to the use of the words 'artificial', 'synthetic' or 'chemical' to describe manufactured products. We prefer to use neutral terms such as mineral fertilizer and manufactured fertilizer, in order to distance ourselves from the chemical and agrochemical industries which have their own public relations priorities to deal with.

During the 1980s, particularly in the UK and France, the industry gained valuable experience dealing with the nitrate in water issue, by putting forward carefully researched, balanced, rational arguments to explain that the nitrogen cycle is an essential life mechanism, and that nitrate in the environment is not solely due to agricultural processes. The campaign of advertisements, leaflets, educational material and careful lobbying had a broadly beneficial effect, perhaps not in changing overall public perception towards fertilizers, but in ensuring that legislation controlling nitrogen use was not overly severe.

Food Surpluses

This period was also characterized by growing food surpluses in the West and several well publicized famines in developing countries, particularly in Africa. Supply control measures in West Europe and USA effectively reduced surpluses, but also had a negative effect on public opinion towards the agricultural industry. It is difficult to justify policies which subsidize farmers who take land out of production while elsewhere people starve.

Some good came out of it though: the policy-makers began to take a closer look at alternative production systems which were gaining momentum, including the concept of 'Integrated Crop Management' (ICM) - which in its most simple form, aims to provide a package of measures for arable crop production that both addresses current environmental concerns and is financially viable. Integrated farming systems, such as those promoted in Britain by LEAF; Germany by FIP; Spain Agrofuturo, and others in Sweden, France and Luxembourg, usually have a crop rotation sequence that includes a legume to supply nitrogen and provide animal feed. They are attracting strong interest, not just from policy-makers seeking to shift support from production incentives to rewards for reduced production and improved environmental quality, but also from other links in the production/distribution chain, looking for differentiation in a market where the consumer is conducive to purchasing food perceived to be grown in a superior environment. Powerful retail groups in some countries are having a profound effect on public opinion by encouraging growers to adopt accreditation and quality assurance schemes, the resulting package label thereby communicating to the consumer a symbol of environmental acceptability.

The drive towards Codes of Practice, BAT, Accreditation Schemes, ISO9000, etc, will inevitably lead in the direction of food labelling, and several of the 'integrated' or 'alternative' protagonists are participating closely with retailers to define such 'quality' symbols. In sophisticated vertically integrated production/distribution/retailing systems, food safety legislation pushes in the same direction with the additional requirement for 'trackback' source identification.

The refinement of agricultural systems to satisfy the well-fed Western consumer does not, however, solve the immense problems faced by developing countries, where the use of fertilizer also faces problems associated with perception.

Fertilizers, Population and Hunger

Predictions 30 years ahead, particularly those by economists, are invariably wrong! But on the demand side, there is widespread agreement among the experts regarding population growth and its characteristics, and the statistics are awesome. It is broadly agreed that:

- world population will exceed 8 billion by 2025
- most population increase will be in cities— urban populations will grow from 1 to 4 billion.
- most agree that food supplies must more than double by 2025

There is little agreement, however, on how to achieve the necessary supply. Views range from the optimistic "there is no problem, technological advances have always closed the food/population gap" view, to the Malthusian pessimistic view that predicts disaster unless effective population control is implemented immediately.

Regardless of which view you prefer, the productivity improvement challenge facing world agriculture in the next 30 years is enormous. Coupled with the unprecedented growth rate in world population, the proportion living in developing countries will increase from 75% to 83% by 2025. Greater urbanization and income growth will increase the demand for food and will shift diets from roots, tubers and lower quality grain staples to higher quality cereals like wheat and rice, livestock products and vegetables. Urbanization requires better markets, infrastructure, distribution, storage, food security - all things we take for granted but which are largely absent in many developing countries.

Since the 1950s, the doubling of cereal output came from:

- area expansion
- greater intensity of land use (irrigation, etc)
- yield increases

The irrigated area doubled from 1950 to 1980, but has since slowed considerably due to competition for water and risk of salinization. The natural resource base is under stress in many developing countries already. In some cases as much land is lost to erosion and salinization as is brought into production through irrigation and expansion. So the current (conventional) view is that the next doubling of food production must come from increased yield from the existing land base, while maintaining (or improving) the natural resource base. A 0.1% pa yield increase from 2010 to 2025 substitutes for about 25 million ha of rainfed cropland. Most serious predictions require at least a 2% pa increase in global food production. But few systems have sustained increases of over 2% per year, and these have often been at the expense of resource degradation.

In Sub-Saharan Africa productivity levels are among the lowest in the world with cereal productivity achieving only 40% of world average. Despite more than 80% of the region's population being employed in agriculture, there is insufficient food produced to satisfy domestic requirements. The per capita production of foodstuff in Africa is already the lowest in the world and it is getting worse. External debt as a percentage of GNP for the region is the highest in the world and the ability of the region to fund food imports to meet the deficit is deteriorating. The alleviation of poverty and the development of food security through the rehabilitation of primary agriculture is the foremost concern of the international community and policymakers.

International Trade

An important factor contributing to cyclical concerns over food supply is the fact that most food is consumed in the country in which it is produced. That is, a relatively small percentage of the world's food production enters into international trade. If food demand doubles, grain consumption (wheat, rice, maize) will grow from 1.9bt to 3.8bt in 2025. International trade now accounts for 200mt, around 10% of the total production. It is true that much of the trade in food is between net exporting countries and takes place to add variety to diet and to overcome seasonal shortages of domestic production. The number of net food exporting countries is small, and they tend to be highly developed, high income, low population growth countries. The poor, developing nations have limited capacity to utilize commercial food imports to offset domestic food shortages. Even if the expected 3 billion urban dwellers were to be fed by trade, exports of grain must increase by 4 times (200mt - 800mt) assuming 200kg per capita, in 30 years. This would be physically, biologically and economically a huge task. The USA currently provides about half of the world's grain exports - to maintain that share, USA grain production would have to triple by 2030.

Fertilizers the panacea?

According to the 2020 Vision research and consultations (IFPRI), "the use of mineral fertilizers will have to be substantially increased to meet food needs by 2020, especially in developing countries, although organic sources can and should make a larger contribution to supply plant nutrients. Fertilizers also have a key role in enhancing the natural resource base. 2020 Vision research forecasts that between 1990 and 2020, global fertilizer demand will grow, on average, by 1.2% per year to 208 million tons in 2020, a significantly lower rate than the 2.8 percent rate in the 1980s.

Average annual growth rates are projected to be around 1.8-2.4 percent in Africa, Asia and Latin America. Asia will account for over half of the global growth".

Average fertilizer use in Sub-Saharan African countries is low (estimates range from 9-11 kg per hectare) and irrigation is from 4-6% of cropped area. Depletion ('mining') of soil nutrients is a critical constraint to food production in Sub-Saharan Africa. The projected growth in fertilizer use will be inadequate, given nutrient requirements for food production and for resource conservation. Fertilizer applications are low because of high prices (resulting from thin markets, lack of domestic production capacity, poor infrastructure and inefficient production systems), insecure supplies, and the greater risks associated with food production in marginal areas. In Sub-Saharan Africa, erosion, land degradation and the depletion of nutrients often go together. A sustained rate of growth of yields of the magnitude needed requires in-depth scientific research, research on improved practices under farm conditions, improved incentives, adequate attention to fertilizer supply, and improved transport infrastructure.

And yet, research budgets have been cut. After reasonable growth in spending throughout much of Africa in the 1960s and early 1970s, growth largely stopped in the late 1970s. For comparative purposes it is often more meaningful to relate agricultural research expenditures to the size of the agricultural sector. From the early 1960s to the mid-1980s, these research intensity ratios almost doubled for developed and developing countries alike. Since then, China's research intensity ratio has stagnated and the ratio has also shrunk considerably for many national research systems throughout Africa.

Raw materials, capital investment, and technology do not appear to be critical constraints to future fertilizer production. In most developing countries the problem is not excessive, but insufficient, fertilizer use. Therefore, the major challenge is to promote a balanced and efficient use of plant nutrients from both organic and inorganic sources at farm and community levels to intensify agriculture in a sustainable manner.

Nutrient Management

Johnston supports a 'nutrient management' approach - which implies management of all nutrient sources: fertilizers, organic manures, waste materials suitable for recycling nutrients, soil reserves, biological fixation and bio-fertilizers, etc, in such a way that yield is not knowingly jeopardized whilst every effort is made to minimize losses to the environment. Problems associated with an imbalance of applied nutrient is illustrated by a recent article in the New Delhi Indian Express - "the gap between the controlled price of urea (N) and the decontrolled prices of phosphatic (P) and potassic (K) fertilizers are apparently creating imbalances in their use. Against the optimum N,P and K ratio of 4:2:1 and an actual ratio of 5.9 : 2.4 : 1 just before decontrol, the ratio has now become 9.5 : 3.1 : 1. The farmers are clearly using more urea than the other fertilizers because it is cheaper. But this is neither good for the soil nor for productivity. The Planning Commission has therefore emphasized that the imbalance in the use of different nutrients is likely to have serious adverse implications for soil fertility and productivity, and it has called for urgent action to correct this imbalance."

Best Practicable Environmental Options

This is fast becoming a vogue phrase in the sustainability debate. It is appropriate in this context because agriculturalists and environmentalists are still arguing about the best way to replace lost nutrients - there are inorganic and organic methods such as compost and nitrogen-fixing legumes that add nutrients to the soils.

According to Carlos Banaante, director of the Research and Development Division at the International Fertilizer Development Centre (IFDC), "organic fertilizers, such as composted livestock manure and plant residues, help to maintain the soil's organic matter and supply nutrients. But the nutrients supplied may not be sufficient. The best management is the use of both inorganic and organic sources of nutrients". This is also the main message behind FAO's development of 'Integrated Plant Nutrition Systems' (IPNS).

But some members of the environment community disagree - "The assumption that we should keep adding nitrogen fertilizer to soils indefinitely is weak", says Jonathan Landeck, director of international programs at the Rodale Institute. "The ideal agriculture is that which does not incorporate any synthetic chemicals [emphasis added]. For those who say that organic fertilizers are not viable in the long run, I have to point out that synthetic fertilizer use will likewise reach yield plateaux. Additionally, use of organics could mean fewer energy inputs, making them cheaper than synthetic chemicals. But we don't know because we have not been investing equally in research on agriculture that is clean of synthetic chemicals". The operative word in Landeck's statement is ideal - of course IFA recommends optimum use made of local sources of nutrients, including organic materials, but normally the quantities and/or types need to be supplemented by mineral fertilizers to achieve satisfactory levels of productivity.

Some perceive agriculture as an environmental enemy. In some of the highly productive Green Revolution areas, dramatic increases in food production have been associated with environmental degradation: water-logging and salinization of soils from irrigation; contamination of surface and groundwater; loss of beneficial insects; build up of resistance in insects and weeds, etc. "Agriculturalists and environmentalists are becoming better informed", says Peter Hazell of IFPRI. "Few agriculturalists now think that Green Revolution technology should be applied to fragile areas. Similarly, in highly productive areas, more environmentalists agree that we have to continue to use modern inputs, but do so in a more environmentally responsible way."

Perhaps the greatest opportunity for increased yield potential is in plant breeding using techniques of genetic transfer. This is where the objectives of agriculturalists and ecologists may finally converge - because the maintenance of the largest possible gene pool in nature is now equally important to both.

Environmental Reconciliation

During the 70s and 80s environmental pressure groups succeeded in changing attitudes within major policy-making bodies, governments, international organizations and NGOs. It was a difficult period, not just because revolutionary lobbyists simply shouted slogans and were unprepared to seek practical solutions, but also because it encouraged a kind of 'anti-industry' philosophy among many important players in world agricultural development. This made IFA's relations with organizations such as FAO for example, more difficult. The highly productive FAO/FIAC Fertilizer Program provided the catalyst for much effective action, working with developing countries, with support from the fertilizer industry and other donors. At the end of 1993 FAO closed its FIAC Liaison Office situated at its headquarters in Rome, as the environmental groups exerted considerable pressure to obtain the same status as the fertilizer industry through FIAC.

Several factors have combined to shift attitudes and perceptions yet again in recent years. The United Nations Conference on Environment and Development in Rio in 1992 put the concept of sustainable development firmly on the map, and a new UN Commission on Sustainable Development (UNCSD) was formed. No longer was industry seen to be the villain, but a partner with whom to work to solve the problems of resource use, pollution, global warming and feeding the world's growing population. This was further reinforced following the 1994 inter-governmental conference in Cairo on world population. The food-population equation was no longer viewed in simple rich–poor; north–south; hungry–overfed terms, but rather in terms of complex relationships between (1) development to maintain and enhance living standards (2) reduced population growth and (3) greater environmental protection.

In other words, there is a growing acceptance among the campaign groups that there is no such thing as zero environmental impact, and that 'sustainable development' includes an assessment of the trade-off between environmental costs versus human / industrial benefits.

In his stated 'war on hunger' the present Director-General of FAO, Mr Jacques Diouf, recognizes the importance of sustainable production alongside policies to ensure that population growth rates are lowered through the improvement of economic conditions. Mr Diouf said in 1994, "we in agriculture have the responsibility to ensure that there are technologies which are more efficient, yet respect the environment. That is the only way". IFA maintains close links with FAO which continues its fertilizer related activities through its new Plant Nutrition Management Service.

FAO's ambitious plans for a World Food Summit in November 1996 have also produced some constructive statements regarding future fertilizer use - "The adverse effects on the environment of the increased use of fertilizers and pesticides can be minimized if the process of intensification is carefully managed in the context of the potential offered by approaches such as the Integrated Plant Nutrition Systems (IPNS) and Integrated Pest Management (IPM) [also ICM, LEAF, etc]. It is noted, however, that enhanced fertilizer use is a necessary ingredient of the move towards more sustainability in the areas where too little fertilizer use is associated with nutrient mining and soil degradation. This is the case in many countries of Sub-Saharan Africa and the risk here is that the economic and policy environment may continue to be hostile to the adoption of practices to prevent soil nutrient mining." *FAO World Food Summit draft documentation, September 1995*

Similarly, the World Bank is going through a process of reform, and there is a detectable awareness within the Bank of its willingness to work more closely with industry and NGOs. IFA/World Bank roundtable meetings are a valuable catalyst for action in this respect, and IFA hopes to be able to provide the stimulus for an even greater degree of cooperation among all groups with an interest in world food security.

UNEP, the United Nations Environment Program and IFA are also producing a report on The Fertilizer Industry and the Environment, further reinforcing the view that our industry is a legitimate partner in the environment/development rationalization process.

A good example of what can be achieved when all interest groups cooperate for a common purpose is the Landcare program in Australia. Initiated by a milestone agreement between the farmers' federation, government and the country's most powerful environmental organization, it begins to attach the 1990s 'Duty of Care' philosophy to the responsibilities of sustainable land management - but not just by farmers - the hallmark of all Landcare projects is that they involve the whole community. Landcare focuses on the catchment as a logical, geographical and manageable area for environmental improvement, rather than individual landholdings. It is politically neutral and has attracted strong support from commercial sponsors and agencies not immediately associated with land management.

Recent high profile events have shown the strength of public opinion which can be motivated on certain issues - for example the attempted disposal of the Brent Spar oil platform in the North Sea - Shell naively allowed itself to be sucked into a direct confrontation with Greenpeace. A classic 'David and Goliath' struggle ensued, and of course natural sensibilities cause most people to side with David. But Shell should have made it clear from the outset that the problem of how to dispose of Brent Spar in the most 'environmentally correct' manner was only partly Shell's problem - in fact it is actually society's problem! Society has enjoyed the benefits of the oil it has produced from the sea bed - hence society must decide how to dispose of it (and the great number of platforms which will become due for disposal in years to come) especially as it transpires that the British taxpayer is picking up most of the bill anyway!

If Shell had commissioned an independent audit and feasibility study beforehand, it would have reached the same conclusion as will probably now become clear - that disposing of Brent Spar in a deep sea location probably is the best option. Shell might then have saved themselves much aggravation, loss of credibility and fuel sales!

The apology subsequently offered by Greenpeace focused the media's attention onto the activities of such environmental activists and to reassess the way in which such issues are reported to the public. Shell have also recently invited Greenpeace's participation into the decision-making process.

Conclusions

The concept of sustainable development, cited extensively in this paper, implies a more integrated approach to agricultural development issues - fertilizers are now seen as part of a total package of measures to maintain and improve soil nutrient levels. Fertilizers are no use without adequate water; seeds are no use without proper cultivation; technology is no use without education, etc.

Also a more cooperative approach towards development issues is highly desirable. There is a profusion of agencies, institutes, organizations and societies with an interest. The current drain in research funds requires available resources to be used most efficiently - to avoid duplication, lack of direction, wasted results, temporary solutions, etc.

There is a detectable renewed spirit of cooperation among all stakeholders to solve the fundamental problems of world agriculture. The environmental movement is becoming more sophisticated and approachable - they're no longer shouting slogans, but developing their own research and making detailed scientific demands. In many countries a political force to be reckoned with, they are often well organised, well funded, and in most cases well respected. The industry is still not 'off the hook', but fertilizers are no longer seen in isolation, and there is renewed attention by many of our members on the positive aspects of fertilizer use, rather than adopting defensive positions when faced with scrutiny. Indeed, IFA's establishment of an External Relations Working Party testifies to the increased willingness on the part of the industry to communicate openly and constructively with all other key interested parties. We believe that a clear vision and a confident worldwide presence is vital to the future wellbeing of the industry.

Key Sources

The Efficient Use of Plant Nutrients in Agriculture
A E Johnston, Lawes Agricultural Trust Senior Fellow, IACR Rothamsted, UK

A 2020 Vision for food, agricuture, and the environment in sub-Saharan Africa
International Food Policy Research Institute IFPRI, Washington DC

Agriculture and Food Needs to 2025: Why we should be concerned
Alex F. McCalla, Consultative Group on International Agricultural Research CGIAR, Washington DC

Agriculture and Fertilizers in Perspective
Bockman, Kaarstad, Lie, Richards, Norsk Hydro a.s., Oslo, Norway

"In much of Africa, where crop yields will have to increase, the "mining" of soil nutrients is now helping to push average crop yields into decline. In much of South Asia old irrigated lands are becoming saline and waterlogged and are going out of use almost as fast as new irrigated lands are coming into production. From Honduras to Java, soils are washing away on newly cleared sloping lands. In East Asia, South Asia, and Central America, the natural biological controls for crop pests are being poisoned with farm chemicals, even while the pests themselves are becoming more poison resistant.

Worsening this crisis today is a paralyzing technical debate between agriculturalists and environmentalists over what environmentally sustainable farming would actually look like. Production-oriented agriculturalists argue that environmental protection - especially protection of forests and topsoil - can be advanced through modern, input-intensive farming. Environmental advocates, by contrast, associate high-input farming with chemical pollution, a faster exhaustion of water supplies, and a dangerous loss of biodiversity. They feel it is better to hold onto traditional farming techniques suited to local ecologies and to the circumstances of ordinary resource-poor farmers.

These divergent technical preferences between agriculturalists and environmentalists have helped paralyze the international policy community. Bilateral and multilateral assistance organizations, not wishing to antagonize powerful environmental lobby groups, have become increasingly wary of sponsoring input-intensive, science-based farm modernisation projects. This is one reason international assistance to farming and to farm research has recently faltered. Yet the number of people needing food in the developing world grows larger every year, while the quality of their resource base continues to degrade.

How can this paralyzing policy deadlock be broken? Paying more attention to geography and to politics is one way to start. In some regions of the developing world the agriculturalists are right to argue for more use of purchased inputs, while in other regions less input use is needed, so the environmentalists are right. In some regions neither group will be entirely correct, since appropriate technical changes will not take place without more fundamental political and social change."

From *Sustainable Farming: A Political Geography* R.L. Paarlberg, 2020 Vision, IFPRI

"Today's leading Malthusian is Lester Brown, President of the WorldWatch Institute, a Washington-based environmental group. He argues that China's growing demand for grain imports could trigger food price shocks, in turn causing starvation for hundreds of millions around the world.

The world's population doubled between 1950 and 1988, yet food supply kept pace with demand. Pessimists had failed to anticipate the 'green revolution' of agricultural productivity, as scientists devised strains for high-yielding cereals. In Asia, wheat yields rose five-fold between 1961 and 1991. Output was boosted further by better farming methods, more irrigation and more chemical fertilizers.

Every year the population of the developing countries expands by almost 90million - as it were, another Mexico. UN estimates suggest that by 2020 world population will exceed 8 billion, up 45% from today. Food demand will rise faster still: as people are lifted out of poverty, they eat more.

There are some worrying signs on the supply side, too. Yields of rice and wheat in Asia are still rising, but much more slowly than in the 1960s and 70s. Growth in the use of fertilizers has slowed worldwide. In many African countries government spending on research fell in the 1980s, after rising for decades.

In Asia many irrigated areas have become saline or waterlogged. pests have developed resistance to chemicals. In many countries, fertile areas still uncultivated are often precious habitats for wildlife as well. In some areas, such as northern China, irrigation has led to water shortages.

Yet for every headline-grabbing prediction of doom, there are sober reports predicting the opposite. A forthcoming study from the UN's Food and Agriculture Organization, for example argues that Mr Brown has miscalculated China's productive capacity. In Washington, the International Food Policy Research Institute advocates more investment in agricultural research, but sees no immediate constraints on food supply. Our estimates show that the world is perfectly capable of feeding 12 billion people 100 years from now, says Per Pinstrup-Andersen, Director General of IFPRI.

The growth in crop yields in many areas may be slowing. But wider use even of basic modern techniques could still boost food supply: in Africa for example, fertilizer use is only a quarter of Indian levels. And technology can still promise dramatic advances. Biotechnology may yet revolutionize farming worldwide. The environmental problems brought by modern farming are real enough (though the likeliest alternative, traditional methods spread to every pocket of cultivable land, might well have been worse). But it is unlikely that the world will let them seriously restrain food production.

Arguably, the true issue is not the risk of global food shortage in the next century, but the real food shortages that specific areas and classes suffer today. The UN reckons that more than 700m people in poor countries are chronically undernourished. They are the victims not so much of food scarcity as of poverty."

From: *Will the world starve?*, The Economist, June 10th 1995

Marine Cultivation—A New Area for Fertilization

Dr. Espen Hoell
Norsk Hydro a.s.

Whilst enjoying affluence in a limited part of the world, we are overlooking the fact that the outlook for global food supply for the next 100 years is relatively dismal. Food production per capita is already decreasing, and there is nothing to indicate that UN's prognosis for population expansion is not reliable. If we are to be prepared for the worst, then we must seek new ways of increasing the production of food and raw materials. Through the research program MARICULT, Norwegian research scientists and NORSK HYDRO have pointed out the possibilities and advantages offered from extensive utilisation of the sea for future food production. The program offers many interesting opportunities for the Norwegian fishing and seafood industry and point to possibilities to cope with the global food demand.

Background

It is accepted that the world will not be able to support more than 10-12 billion people by means of fully productive agriculture i.e. the population we are very likely to see within the next two generations. A doubling of global food production will require 40 percent more farmland, a similar increase in the genetic improvement of livestock and vegetation, improved technology and reduced production losses. This will require substantial efforts in the years to come, and many unexpected problems may arise. The main uncertainty in this prognosis is the access to an adequate supply of water.

Despite these relatively dismal prospects, relative little attention is being paid to the future global supply of food according to the Worldwatch Report of 1995. On the contrary, western nations seem to be more concerned about domestic problems caused by food surpluses. The media raised the issue of global food supplies at the 1994 Cairo Conference, but other topics received more attention. Although others, as FAO, seem to believe that the global population can be fed also in the future, provided increased effort is put into education, research and development as well as extension services in the developing nations. This includes development in available and proper use of plant fertilizer. Sadly the available resources are decreasing. Hence any future difficulties in feeding the global population may not first be due to inherent difficulties in food production, but in lack of foresight to meet the problems before they become acute. Politically, the issue appears to be dead. How reliable is the prognosis, which implies that our children and grandchildren will experience a completely different situation with regard to the global supply of food?

Global population has already increased at such a rate that effective population control alone can not be relied upon to solve the world's food problem, although it is quite obvious that population expansion is the primary cause of the problem. The consequences of unsuccessful population control are far too serious. Subsequently, it is our responsibility to seek alternative methods of food production. Time passes quickly, and all possibilities should therefore be kept open.

More than 90 percent of the world's protein requirements are today covered by agricultural products, while fish and aquacultural products account for no more than 5 to 10 percent, although the primary production is of the same order in the marine as in the terrestrial system and the oceans area cover 70% of the earth's surface. Global utilisation of naturally produced sea food has most likely reached its limit. FAO has estimated that the world's ocean is capable of providing annually 100 million tons of fish and other sea food, a level at which the fisheries has stagnated the last decennium. Excessive exploitation of most species in recent years has resulted in a global shortage, and the regulation of natural resources has become an international issue.

Globally, fish-farming has experienced substantial growth and is expected to continue expanding, but access to raw materials for the production of fish food is a limiting factor for further expansion. Conventional fish-farming represents basically an effective way of processing ocean resources, rather than an entirely new source of food production. An exception is presented by species which feed on vegetation.

The production of marine plants which depend on sunlight and utilisation of nutrients in the photosyntesis is in the same order as conventional agricultural vegetation, although the sea constitutes no more than 5-10 % of the protein consumption. This implies that our utilisation of the primary production for food purposes is far more efficient on land than at sea where we basically hunt the resources. In reality, the sea is the world's only accessible biotope which has a sufficiency large potential for increased food production, apart from the tropical rain forests. If this potential is to be enjoyed, we must learn to cultivate the sea in a manner which is both effective and environmentally acceptable. This presents an enormous challenge, and we must secure it is kept within the sustainable limitations for acceptable impact on the marine environment.

The importance of nutrients for marine production.

In recent years, research scientists from Norwegian marine institutions and organisations, Norsk Hydro and The Norwegian Research Council, have completed a study to present some solutions to the above-mentioned problems. The study concludes that we may succeed in increasing marine production in a profitable and environmentally acceptable manner. The study has resulted in a proposal for an extensive research program with international participation, called MARICULT. Some of the fundamental principles are described below.

Natural fertilization forms the basis of all marine production, by means of deep nutritious water becoming mixed with surface water in which algae grow provided light is available. Geographically, there are very large differences in the extent of natural fertilisation, and almost 90 percent of the all oceanic surface water can be regarded as a desert. The world's richest fishing banks are blessed with continuous streams of nutritious deep water streaming up to the surface, known as "upwelling areas". Examples of such regions are the coast of Chile or Peru and the western coast of South Africa. Certain regions of the northern seas are also relatively well-fertilised by natural means, and provide the basis for the Norwegian fishing industry. The question has been raised as to whether or not we can influence this process so that the value of our marine resources may be increased at some time in the future.

There are large differences in natural fish production in different ocean regions. Ocean regions with continuous upwelling of nutritious deep water represent approximately 0.1 percent of the world's ocean surface. The production of algae per unit area in these coastal regions is approximately six times higher than in the open sea, and three times higher than in typical coastal regions, but fish production per unit area is 70,000 times higher than in open sea regions and more than 100 times higher than in typical coastal regions. This is explained by abundant natural fertilisation, which apparently leads to shorter and more effective food chains.

Approximately 50 percent of global fish production is concentrated in the "upwelling" regions confined to no more than 0.1 percent of the total ocean surface (slightly larger than the area of Norway). Fish production is negligible in the vast open seas, which represent 90 percent of the total ocean surface. This also indicates in a convincing manner, our potential for increased production in marine sites.

Practical methods to increase the size of ocean harvests will not surprise the traditional farmer. We must sow that which shall be reaped, we must increase the production potential in critical periods by means of additional nutrition, and we must strive to reduce the growth of unwanted organisms. This is a question of cultivation in addition to fertilization.

In many of the coastal areas, as e.g. the Norwegian continental shelf, the production is limited by the availability of nutrients in a large part of the productive season. Often winter storms bring up nutrient rich deep water, which initiate a spring bloom of algae when light becomes sufficiently for photosyntesis. The bloom consumes all or most of the nutrients, whereafter the upper water masses are more or less infertile the rest of the productive season. Only at some few episodes of summer storms are new nutrients brought up to initiate new production.

It was concluded in MARICULTs preliminary studies, that large-sale restocking of selected species, along with relevant biological activities, would suffice in ensuring increased reserves and catches of these species. Starting from fry, the chances of success will probably be improved if feeding is increased during the early critical periods of growth. This can only be accomplished by increasing the amount of nutrition added to the water during these critical periods, either by means of artificial upwelling, or by direct addition of artificial nutrients. Such measures could be seen as prolonging the spring bloom period.

Artificial marine fertilisation should resemble the natural fertilisation, and the amounts added should be within natural limits of concentration and chemical composition. In the MARICULT experiments, nutrients will be added according to the principles which apply to conventional agriculture; and performed in regions designated for increased algae and zooplankton production, and at times which are most optimal for improving food supplies for the fry of important species. The fertilisation of marine environments as described in this manner, immediately prior to and during spawning, may contribute to the increased growth of selected species with only minor annual variations.

It was also concluded in the MARICULT preliminary studies that the scientific basis for predicting whether nutrient additions would cause increased production, carbon retention or eutrophication problems is fundamentally the same. Understanding of the function and structure of the marine food webs is the key to such predictions. Some of this knowledge excist, but a lot has to be achieved during scientific investigations. It is however believed that we through chemical composition, intensity and frequency of the nutrient additions as well timing of the operations, are able to control the direction of the nutrient transformations.

Empirical models describing the fish yield as function of the nutrients added and the total primary production have been established. This makes predictions of possible cost efficiency possible. There is a significant cost/benefit factor for fertilization in relation to fish yields, indicating potentials for large scale marine cultivation.

Marine absorption of carbon dioxide.

Carbon retention is regarded as one of the results of nutrient addition. It is known that the nutrient availability is limiting the rate of carbon flux from the upper water masses to the deep waters and the sediments. The biological pump in the oceans is probably the most important process for adsorption of carbon emitted to the atmosphere. Thus as much as 99% of the global carbon reservoirs (carbonate rocks excluded) is located in the sediments of the oceans, reflecting the strength of this flux in a geological perspective. Mathematical models for the relation between the new production and the sedimentation have also been established. This implies that even there may be a loss in terms of productivity, this loss is beneficial in relation to the possible climate changes. Today it is however not considered sustainable to use fertilizer in the purpose of carbon sequestration.

Still fundamental knowledge of the relationship between fertilization of the sea and the sea's ability to absorb atmospheric carbon may become imperative for future activities, especially if the worst prognoses for global warming become realistic. International scientific literature has indicated that fertilisation of some kind may be a possible means of improving the sea's ability to absorb atmospheric carbon dioxide. Perhaps, at some time in the future, this may become our only means of handling atmospheric carbon dioxide. We must initially concentrate our efforts on reducing atmospheric carbon dioxide emissions, but the precautionary principle implies that we should improve our knowledge of possible ways of solving the problem.

Macroalgae as an industrial raw rnaterial.

Sea-weeds are global natural resources that mankind has only used on a minor scale. However they has the potential of becoming an important resource, similar to important types of agricultural vegetation. Future production in large oceanic sites may produce a raw material with a wide range of applications, such as protein production for animal and fish food. Macroalgae may be cultivated in such large quantities that it also has the potential of becoming a renewable raw material for bioenergy. It will take a long time to develop competitive sources of bio-energy, but this research is motivated by the fact that the extensive use of renewable bio-energy can contribute to reducing the use of mineral energy sources, and consequently reduce atmospheric carbon dioxide emissions. The international interest for this kind of cultivation is rapidly increasing both in the US and elsewhere.

It is also well-known that macroalgae effectively remove contaminants from sea water. Residual concentrations in the effluent from municipal purification plants for example, may be effectively purified when filtered through a "forest" of sea-weeds. Macroalgae may also be used in a similar manner to purify nutrient-contaminated effluent. Cultivated sea-weeds may be used as a basic raw material for the manufacture of a variety of industrial products, in addition to becoming a source of bio-energy. Large-scale opensea experiments are planned to be carried out in cooperation with European and American research scientists.

MARICULT'S MAIN OBJECTIVE

The preliminary study resulted in a proposal for an extensive research programme with international participation, called MARICULT. The main objective of the research programme is as follows:

To clarify and define the possibilities and environmental limitations for increased effective production and harvesting of food and raw materials from the sea.

According to MARICULT's plan, researchers shall evaluate in depth the results of studies carried out by the various institutions and organizations, and to a large extent, continue to conduct and evaluate risk and feasibility analyses of the concepts presented by MARICULT. Experiments will be limited in size and the research will essentially be fundamental in nature, but with the specific objectives in mind. It is a precondition that the practical implementation of ideas shall be environmentally acceptable, and that increases in production shall be significant. Further development of marine resources, to which MARICULT can contribute, shall comply with the recommendations drawn up by the Brundtland Commission.

Several research projects have been planned under the MARICULT umbrella Founding has been granted by Norsk Hydro, EU's 4 th. framework program and the Research Council of Norway. The international projects will have participants from many European countries, and research will be carried out in a wide range of experimental sites. The program also intend to cooperate with ongoing and planned international research both in the US and the far east. In addition there will be pure Norwegian projects attached, reflecting the high standard of Norwegian marine science and the large potential for marine cultivation along the Norwegian coast.

MARICULT RESEARCH

The main objectives of MARICULT are:

To establish the necessary information on environmental constraints and potentials for increased sustainable production of food, raw material and energy from the ocean, needed for future decisions.

MARICULT will carry out research in two main areas:

1 - Marine fed webs/fisheries

2 - Marine macroalgae

There are three main objectives for the subprogram Marine food webs/fisheries:

To quantify how fertilisation and re-stocking of marine systems affect marine production and harvesting potential.

- To explore the effect of marine fertilisation on the uptake and retention of $C0_2$ in the ocean

- To examine the tolerance of marine systems to nutrient additions (i.e. harmful eutrophication)

The subprogram on Marine macroalgae will have the following objectives:

To develop large-scale farming systems for macroalgae in open oceans and quantify the potentials for biomass production based on nutrient availability and addition. Thereby to evaluate the capacity of seaweed's for trapping of atmospheric $C0_2$ and to evaluate the enviromlnental benefits and consequences of large-scale, open ocean seaweed farming.

To develop improved macroalgae for specific uses (e.g. biogas production and fishfeed) and optimise microbial conversion processes of selected seaweed's to desired products, including genetic improvement of the microbes.

Environmental problems and artificial nutrients.

Some people associate artificial ferdlisation with poisoning and pollution of the environment. This stems from environmental problems which often occur when large quantities of nutrients, unbalanced according to the natural needs, usually mixed with organic material and environmental toxins in high concentrations, are allowed to enter fresh water, fjords and shallow coastal areas. It is important to emphasise that uncontrolled fertilization cannot provide a basis for the sustainable increase of marine production as intended by MARICULT. Similarly, most people will agree that spreading large quantities of untreated sewage or overdosing fertilizer is not the same as sensible agricultural fertilisation.

The intended fertilisation of marine biotopes is best illustrated by forest fertilization, in which the amount of fertilizer added may be doubled as compared to fertilisation by natural means. In marine areas the intended amount of artificial fertilisation should be kept less than the natural supply of the nutrient rich areas.

Whatever the conclusions regarding marine cultivation drawn up at the end of the MARICULT, the results of the program will contribute to clarify important administrative issues related to pollution of the sea by artifical nutrients. For the time being, there is a great deal of uncertainty connected to the effects of planned activities for removing effluent nutrients; activities which are expected to be very expensive for the tax payer. The selection of suitable purification systems must primarily be based on scientific knowledge. The MARICULT program will contribute significantly to improved knowledge regarding critical nutrient dosages and biological indicators for over-fertilisation of marine sites. In this manner, the findings of the program may contribute to future management of municipal effluents.

Ethical, legal and social aspects

Participants in the MARICULT research program are fully aware of the fact that future large-scale cultivation of the sea may lead to consumer conflicts, environmental problems and changes in the structure of biological organisms. Research scientists will be stimulated to seek out possible detrimental effects, as many people may have moral and ethical reservations about extensive exploitation of the sea. These are important issues, and reservations are well-founded.

The social implications of extensive coastal exploitation have not yet been considered, but are aspects which must be treated under the research program. Neither have the legal aspects been evaluated, although it seems clear that the legal consequences are likely to be far less if activities are sufficiently extensive and carried out in the open sea, rather than being limited to selected allotments. Extensive cultivation of the sea must be carried out under national or international administration, whereby the taxation of fishing fleets could be used to finance cultivation activities, as well as regulating the harvesting capacity. Hobby fishing is not expected to be given much further consideration, and there seems to be no reason for changing the current legal rights for hobby fishing. The conclusions of the MARICULT program will indicate more clearly the eventual needs for a deeper analysis of the legal aspects. However these needs are already very apparent, to cope with the present overexploitation of the marine resources.

THE NORWEGIAN VISION

Japan has already started an extensive program for increasing coastal marine production, and Norway may also take an active part in the future. Natural conditions are favourable, we have well-established coastal communities and culture, a well-established fishing fleet, long industrial maritime experience, long experience in fish-farming with large quantities of high quality products and a highly competent marine research community. We are also a major producer of oil and gas, and thus have a special responsibility in contributing to improving knowledge and understanding of the global carbon dioxide problem. Future large-scale cultivation of the sea involves processing and refinement of our marine resources, and Norway's potential is significant. A modest estimation indicates a doubling of the present potential for Norwegian fisheries and fish farming activities.

In a vision for Norway around the year 2050, we are cultivating fish, mussels, crawfish and sea-weeds. Large quantities of fish fry are restocked along the coast each year, and strategic fertilisation is employed during the spawning of indigenous species in order to increase production and reduce annual variations. Fish-farms are guaranteed an ample supply of fish food, and we are a major exporter of sea food and marine raw materials. Far more jobs have been created along the coast, and outnumber those lost by the trapping down of the highly mechanised oil and gas industry.

Globally, the marine food sources have become far more important, and the prices of sea food are higher and more stable than they are today. Cultivation of marine coastal systems is an important contributor to the carrying capacity of the developing countries. A large portion of the maritime industry is involved in the activities.

This was a vision. MARICULT is only a beginning, established to clarify the possibilities and environmental limitations for future development. Nevertheless, the program may be the start of a sustainable blue revolution.

References to some relevant literature.

FAO 1991. Agriculture: Towards 2010. Document 93/24 of the 27th Session of the FAO Conference. Rome 6-25 November 1993.

Hoell, E., A. Jensen, Y. Olsen and T. Bøckmann. 1992. Idea study Marine Production Main report. Hydro-report, 58/9 pp.

Hoell, E., Y.Olsen, C.Hopkins, A.Jensen, U.Lie, E.Sakshaug, H.R.Skjoldal & T. Bøckmann. 1993. The Rjukan Conference. "Can we increase the sustainable harvest and use of marine resources? Possibilities and constraints", Rjukan 27 - 30 april 1993.Norsk Hydro report 1993.

Hoell, E., Y.Olsen and E.Sakshaug. 1995. Feasibility Study Marin Production revised May 95. Hydro report. Doc 95q_PJ9. Hydro Research Centre Porsgrunn.

Indergaard, M. & K. Ostgaard. 1992. Feasibility Study Marin Production. Marine primary biomass; seaweeds. (In Norwegian) Institute for Biotechnologi, Norw. Techn. Univ. Trondheim, 72pp.

Jensen, A. 1992. Feasibility Study Marin Production. Need for better utilization. (In Norwvegian).Institute for Biotechnologi, Norw. Techn. Univ. Trondheim, 33 pp.

Lalli, C.M., and T.R. Parsons, 1993. Biological Oceanography, Pergamon Press.

Longhurst, A. R. 1991. Role of the marine biosphere in the global carbon cycle. In: Chisholm, S. W. and F. M. Morel (eds.). What controls phytoplankton production in nutrient-rich areas of the open sea? Limnol. Oceanogr. 36(8), 1507-1526.

Lovhagen, O., E.Mehlum, B.Spjelkavik. 1991. Floating tapered channels for pumping deep water. Prelimnary study. Norwave 1991.

Newsweek 1994. Empty Nets. Too many Fishermen, Too Few fish. Special Report april 1994.

Olsen, Y., A. Jensen og O. Vadstein. 1992. Evaluation of methods for increased marine production (In Norwegian). Prelinmary study. SINTEF report, STF21 F92057.

Skjarrvold, H. 1993. The agricultural food production. Status and future limitations (In Norwegian). Det kgl. Norske Videnskabers Selskabs Forhandlinger. 1993.

UN 1987. Our Common Future. Report from the Brundtland Commision.

Requirements for a Fully Integrated Fertilizer Program

Tom Larson

Cenex/Land O'Lales

Good Afternoon!

I plan to spend the next few minutes discussing the requirements for a "Fully Integrated Fertilizer Program".

Over the last decade, our industry has used different terms to communicate and market agronomic philosophies.

First, there was Maximum Economic Yield (MEY); then Best Management Practices (BMPs); and finally, Sustainable Agriculture. As you know, the watch word for the "90's" is Precision Agriculture.

Technology, computerization, and environmental pressures have dramatically changed agribusiness and the way farmers and ranchers raise crops and livestock. This time around, farmers themselves are leading the charge for Precision Agriculture. They're eager to collect information through yield monitors and work with their suppliers to make the latest technology work on their acres.

Precision agriculture is knowledgeable people managing information to make agronomic management decisions. Results include selection of appropriate precision technology and variable application of inputs. The successful implementation of Precision Agriculture requires a seamless integration of people, knowledge, and technology.

In a lot of respects, we have been implementing precision agriculture for many years. In the late 40's and 50's our industry started hiring agronomists and farmers applied the same fertilizer blend to all their fields. In the 1960's, prescription blending of plant food allowed farmers to apply different blends of plant food for each field based on a soil test and yield goal for a particular crop.

Today, we can apply specific amounts of plant food to areas within the field based on the technology available today. With precision agriculture, we assess many factors within the field: fertility, disease, weeds, moisture, etc. to increase farmers profitability.

Traditionally, we have worked through the Research/Extension system to move an idea through research to implementation in an organized approach.

1. Someone has an idea.
2. Research is done on that idea.
3. Knowledge is obtained from that research.
4. Technology is the result of knowledge.
5. The technology and knowledge are implemented.

Each era of agriculture has followed this process:

- mechanization
- genetics
- chemicals
- information

However, due to rapid changes in low-cost technology, we have jumped past the research and knowledge steps. Often it appears confusing because change is occurring rapidly. However, we are in the unique position of being on the "ground floor" of a new technology, performing research and gaining knowledge enabled by this newly developed technology. This technology leap allows more people to be involved in the process of implementation of ideas. Growers are no longer excluded from the research/knowledge steps, and, infact, they play an active role in the process. This also speeds the process of implementation of ideas.

Using soil analysis and other collected information, we are proving at the farm level that precision agronomic principles do work.

As the burdens on the individual farmer increase, more acreage, regulations, economic pressure, precision agriculture questions—the vast majority are turning off-farm for help in meeting their challenges. For many, the local retailer is the natural source for assistance.

But not just any person can provide the assistance. Today's farmer needs the expertise to meet agronomic, economic and regulatory requirements. It's increasingly important that agronomic team members are highly skilled in their areas of expertise—whether they are professional agronomists or certified custom applicators.

Which leads us to the next component—KNOWLEDGE.

To serve their customers, agronomy team members need a wide range of knowledge. They need the ability to help producers plan for a profitable crop. And, they need to update their knowledge regularly to keep up with changing technical and agronomic information.

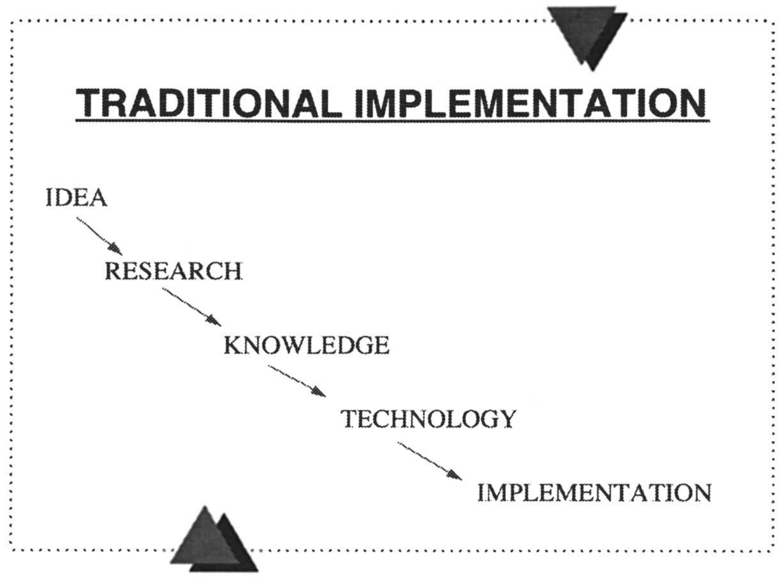
The final element critical to a "Fully Integrated Fertilizer Program" is technology. The days of calculating a single product rate for an entire farm, or even one field are nearly over. The ability to determine precise applications rates of plant food or crop protection products for conditions over small segments of any given field is the future, when it come to economics and environmental stewardship.

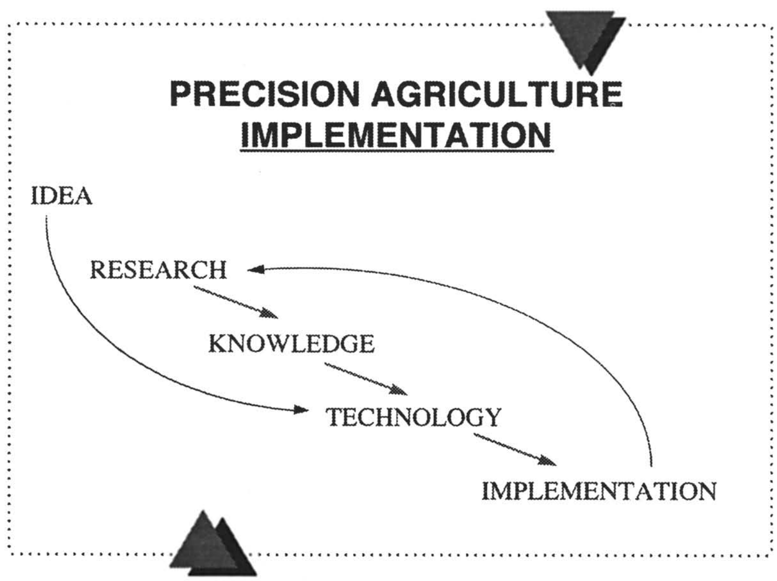
Creating your retail dealers future in precision farming will include complete precision information and application of such things as the planter, combine, application equipment, and computer system.

The integration of people, knowledge and technology becomes key to meeting the needs of farmers in the future.

HISTORY OF PRECISION AGRICULTURE

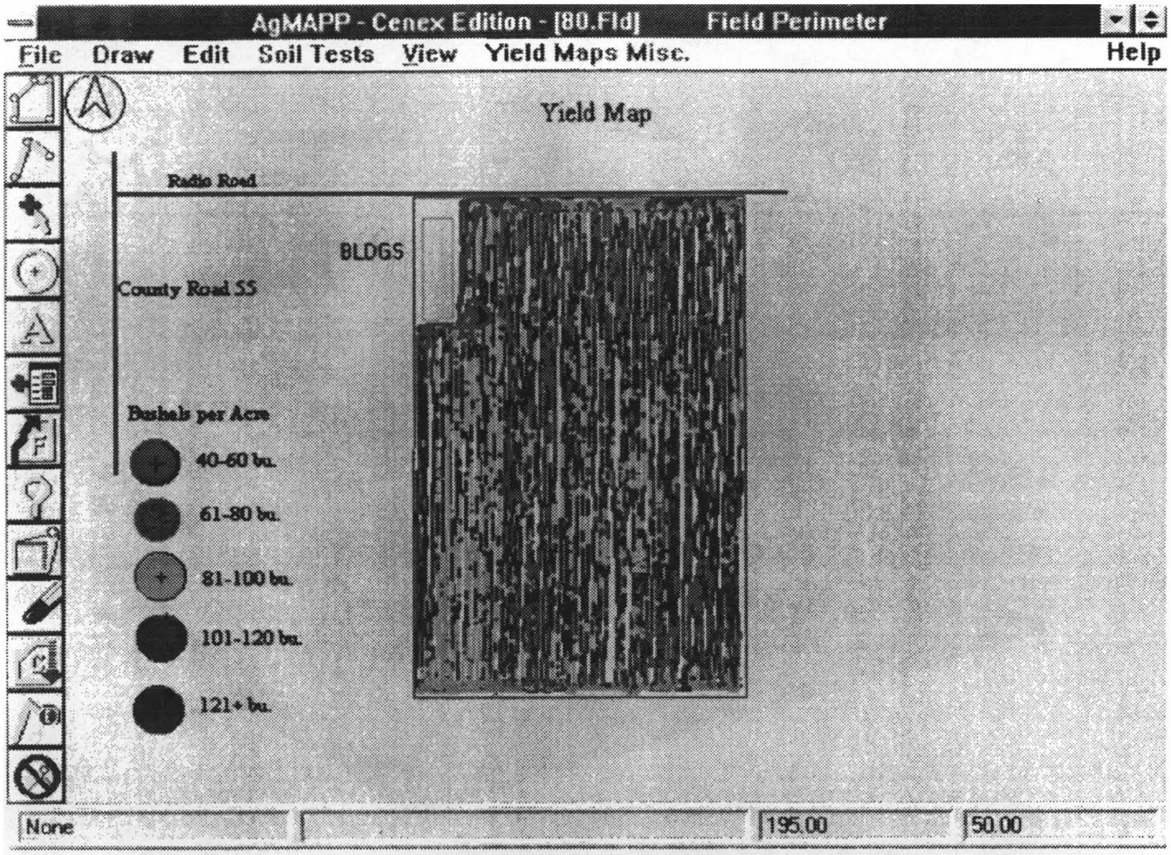
◆ 1950's	First Agronomist
◆ 1960's	Prescription Blending (Plant Food)
◆ 1970's	Custom Application
	Laboratory Services
◆ 1980's	Variable Rate Application
	Sales Agronomists
◆ Late 1980's-90's	Computer Systems
	Grid Sampling/Mapping
	Farm Management Plans
	Precision Agriculture





With precision agriculture, we assess factors within the field.

- **Fertility**
- **Yield**
- **Disease**
- **Weeds**
- **Moisture**
- **Other**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101-120 bu.
121+ bu.
None
195.00
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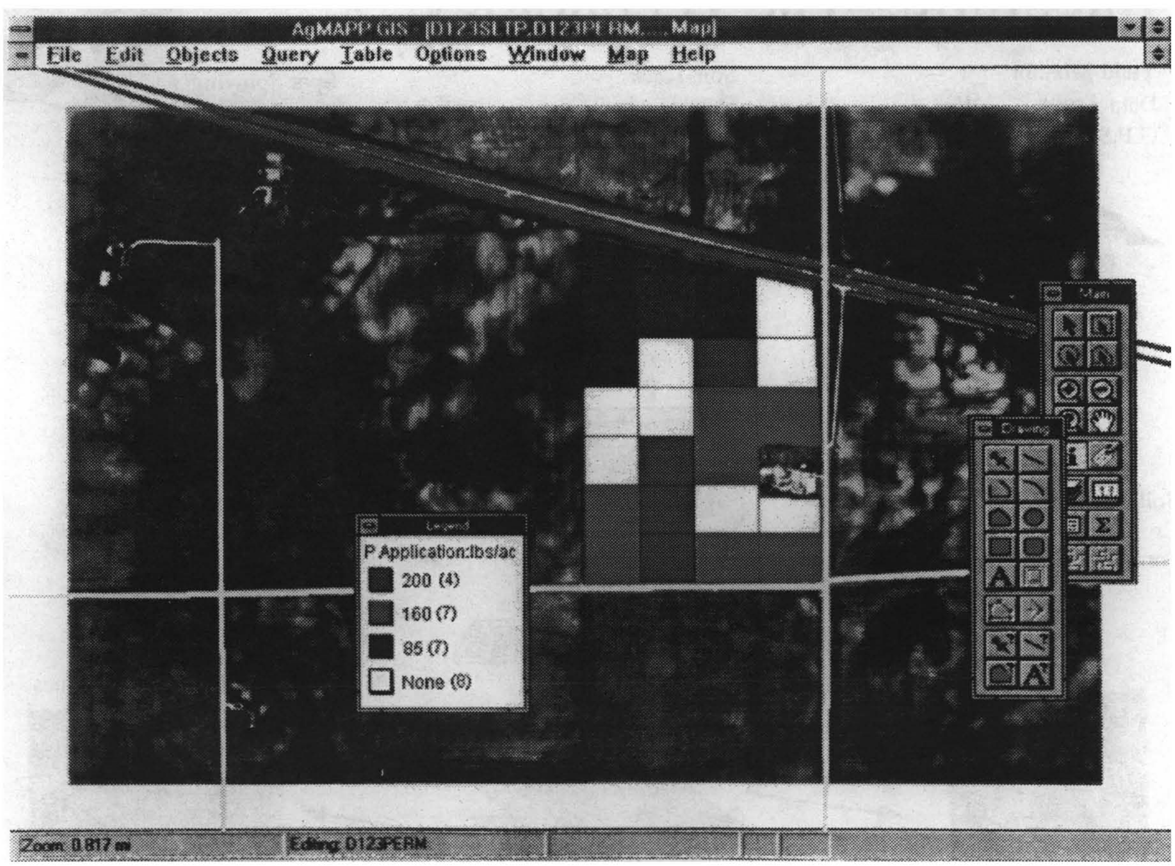
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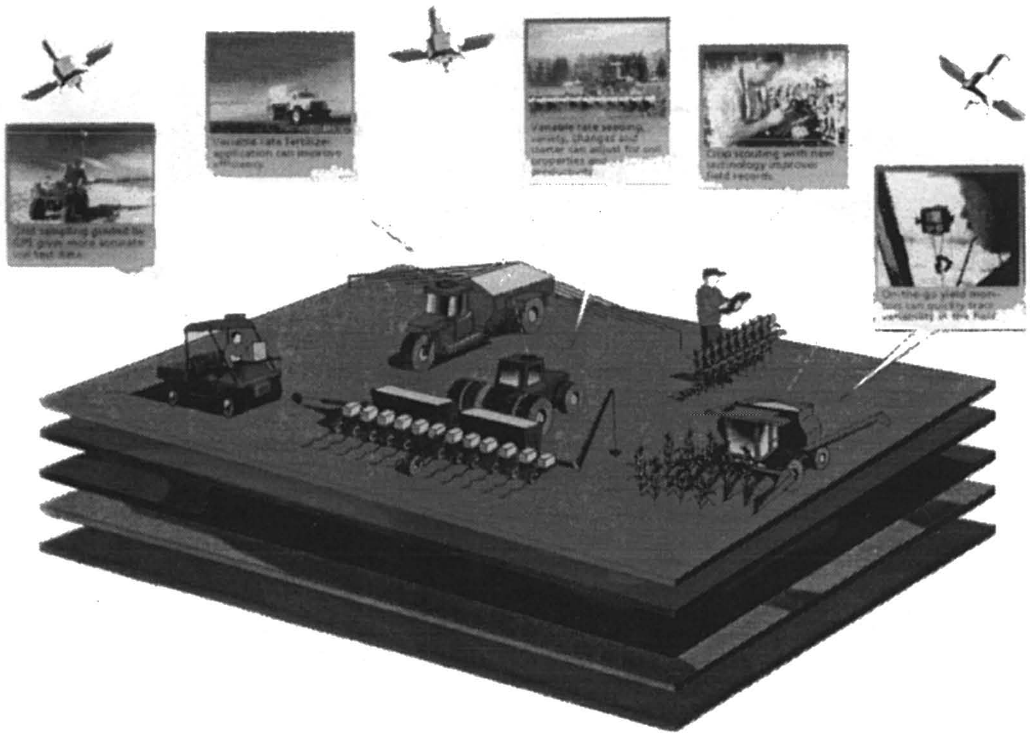
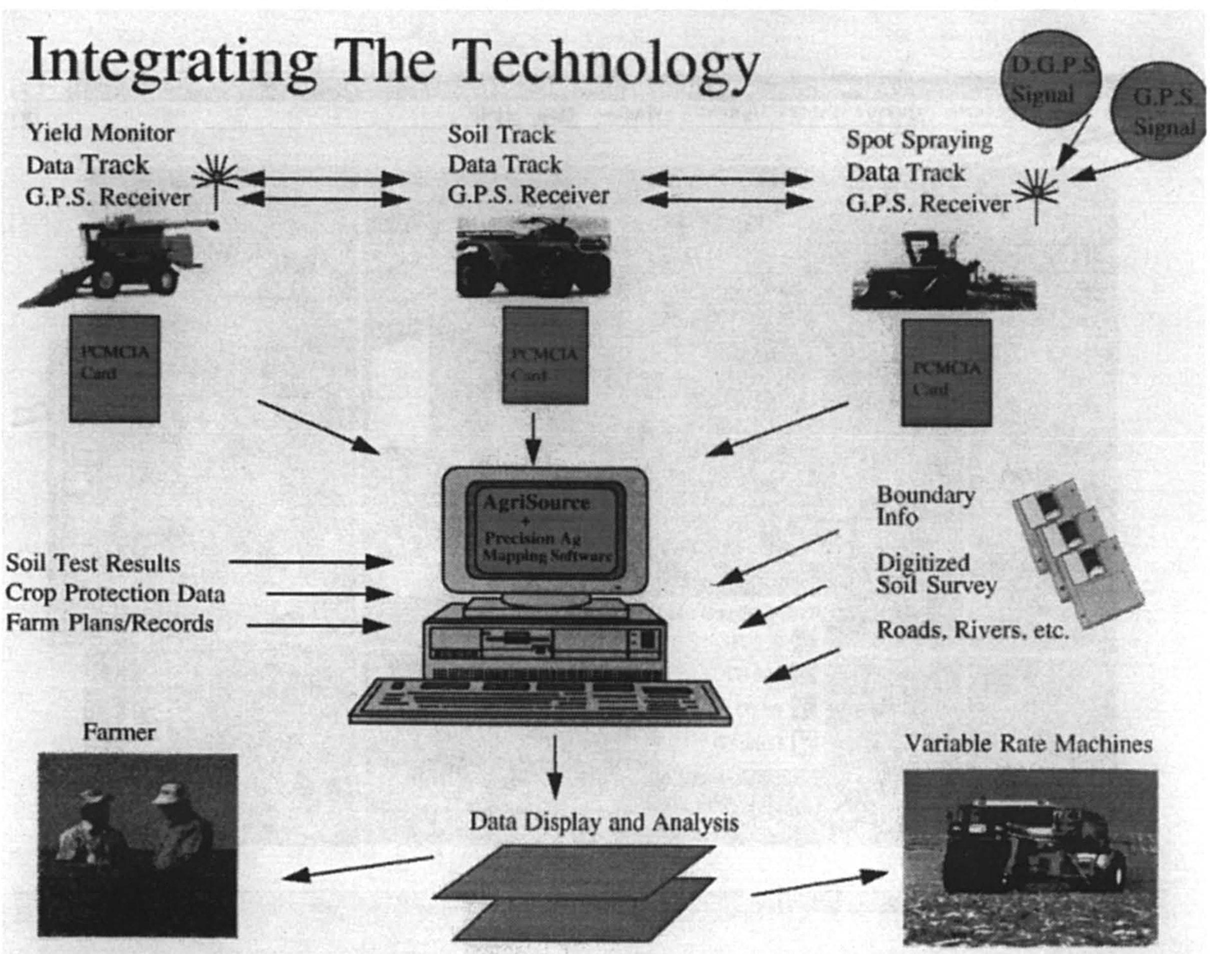
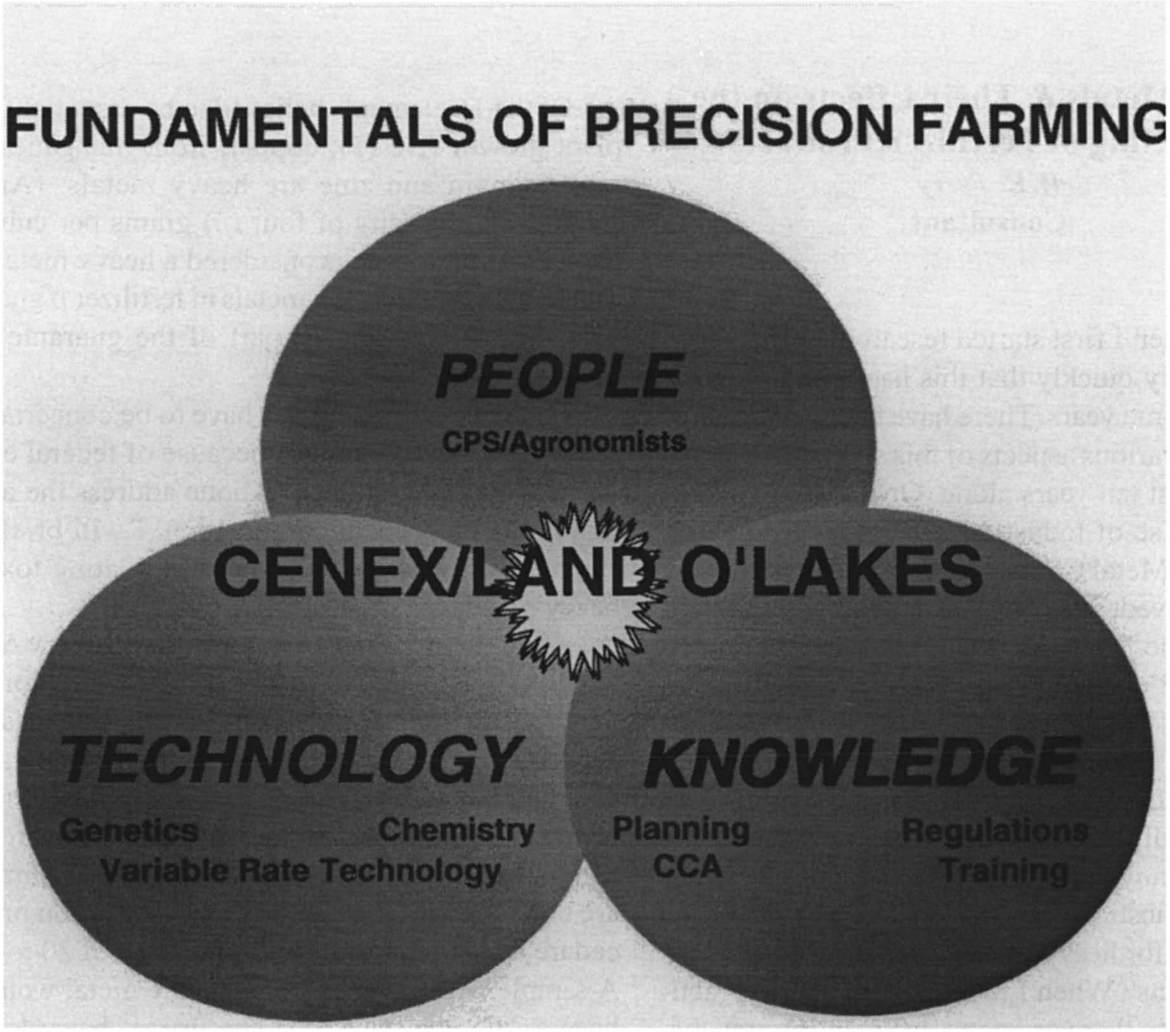
PRECISION AG PUTS YOU IN CONTROL






FUNDAMENTALS OF PRECISION FARMING
PEOPLE
CPS/Agronomists
CENEX/LAND O'LAKES
TECHNOLOGY
Genetics
Chemistry
Variable Rate Technology
KNOWLEDGE
Planning
Regulations
CCA
Training

Heavy Metals & Their Effects on the Recycling of Fertilizer Products

W.E. Perry
Consultant

When I first started researching this topic, I found very quickly that this has been a popular topic for some years. There have been hundreds of papers on various aspects of this subject presented over the last ten years alone. One of these papers entitled "Use of Industrial By-Products Containing Heavy Metal Contaminants in Agriculture" by John Mortvedt presented at a symposium sponsored by the Minerals, Metals & Materials Society in 1992 contained most of what I had wanted to cover in this paper. I will refer to the publication where appropriate.

A few days after I started my research, I received a call from the environmental staff person for a company doing business with one of my clients. His question was quite specific. What are the guidelines for heavy metal contaminants in fertilizer products? When I told him that for all practical purposes there are none, his reaction was disbelief but we had an interesting conversation. We discussed what is regulated in our industry and what is not. After mulling over this conversation for a few days, I decided to focus this paper on the questions put by this outsider to the fertilizer business.

Historically, the regulations dealing with fertilizer production and fertilizer use have been the responsibility of the states. The state fertilizer control official's under the auspices of their national organization, " The American Association of Plant Food Control Officials" (AAPFCO), have developed a Model Fertilizer Bill that defines labeling regulations, statements of guaranteed analysis and tolerances for these analysis. Penalties for violations are left to the discretion of various states. The Agricultural Extension Service of the U.S. Department of Agriculture working closely with the State Land Grant Colleges makes recommendations for fertilizer use. Environmental regulations pertaining to production are usually administered on behalf of EPA by the appropriate state agency.

Of the 16 elements believed to be essential for plant growth five (5), copper, iron, manganese, molybdenum and zinc are heavy metals. (Any metal with a density of four (4) grams per cubic centimeter or above is considered a heavy metal). The levels of these heavy metals in fertilizer if guaranteed must be listed as part of the guaranteed analysis.

Fertilizer manufacturers have to be concerned about certain heavy metals because of federal environmental regulations but none address the actual limits on product composition. I will briefly summarize a few of the statutes regulating toxic heavy metals.

The Resource Conservation and Recovery Act (RCRA) lists eight (8) heavy metals which must be checked to determine if a waste product is a "Hazardous Waste" under RCRA. These metals and their "Toxicity Characteristics Leaching Procedure", (TCLP), limits are given in Table I. It should be noted that, for solids, the TCLP limits are based on the leachate from the extraction procedure which represents a dilution rate of 20 to 1. A sample with 100ppm of leachable metal would have a TCLP of five (5). The use of hazardous wastes are not prohibited in fertilizer products but, if used, the manufacturer must be a registered RCRA facility.

Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA) is also known as the Emergency Planning and Community Right-To-Know Act. Two provisions of this act impact producers of fertilizer micronutrients. The first is the Material Safety Data Sheet (MSDS). The MSDS had its origins in OSHA and Department of Transportation regulations for materials shipped in commerce and originally applied to known hazardous products. Now that even the corner hardware store must keep a file of MSDS's on all chemical products offered for sale, manufacturers are required to furnish an MSDS to customers and distributors for all substances, hazardous or not. The MSDS must list all hazardous substances contained in a product at a concentration of 1% or more giving toxicological information, first aid treatment for various methods of exposure, fire hazards and other basic information. For substances known to be carcinogenic or teratogenic, the de minimus concentration is 0.1%. Since three of our common micronutrients - copper, manganese and zinc are considered hazardous, the MSDS for some products can be quite long.

The second provision under SARA is the Section 313 Toxic Chemical Release Report. EPA has listed several hundred compounds which manufacturers must track if used above certain threshhold values. Releases to the environment through air, water, and off-site or on-site land disposal must be reported for these compounds on an annual basis. Again, copper, manganese and zinc are included on the list. Any hazarduous component that is present in any raw material that is used in excess of the threshhold value must also be included in the report. For micronutrient manufacturers the list of possible components would include arsenic, cadmium, chromium, cobalt, lead, mercury, nickel and selenium since these elements are common contaminants of micronutrient raw materials.

Last, but not least, is the Clean Water Act. This act impacts most fertilizer manufacturers through the National Pollutant Discharge Elimination System, commonly referred to as NPDES permits. This act requires a discharge permit for any point-source water discharge into the public waters. This could include a ditch leading to a stream. The limits imposed for discharges are determined by state environmental agencies and vary greatly from state to state. Heavy metal contaminants, particularly those that affect aquatic life, are normally regulated. This system is being expanded to include non-point-source discharges.

The Clean Water Act also contains the sewage sludge regulations. The closest thing we have to a guideline for heavy metal contaminants in fertilizer can be inferred from the "Standards For the Use or Disposal of Sewage Sludge" - Part 503 of Code of Federal Regulations-Title 40. Table II gives the maximum metal pollutant concentrations for exceptional quality sludge and the annual pollutant loading rate for each of the pollutants. Canada has taken this one step farther and has applied their sewage sludge annual pollutant loading rates to all fertilizer materials. Micronutrient materials being marketed in Canada require a sample calculation based on the actual analysis of the material showing the maximum amount of the product that can be mixed to a ton of product without exceeding their limits.

After this review of the environmental regulations regarding heavy metals contents of fertilizer materials, what should we tell our inquiring environmental specialist? I believe we should tell him that there is really no problem with potential heavy metal contamination from the use of properly applied fertilizer products.

As an example, let us refer to Exhibit I. I have intentionally picked as an example an emission control dust from the electric furnace production of steel from scrap. This product is a listed hazardous waste (KO61) under RCRA and was given a specific exemption from EPA when processed into a fertilizer product. The product will usually exceed the TCLP test for both lead and cadmium. In this example, I have assumed we wish to apply 10 pounds per acre of zinc from a KO61 flue dust derived fertilizer which contains 20% zinc, 2% lead and 0.1 % cadmium. These would be typical values for such a product. To accomplish this, we would need to apply 500 lbs/acre of a fertilizer (5-20-20 was chosen as an example) containing 2% of zinc. In this case the 5-20-20 would contain 10% by weight of the 20% zinc raw material. The amounts of the heavy metals applied are given in Exhibit I. An application of 10 lbs/acre of zinc is considered a remedial application rather than a maintenance application.

I consider this to be a worse case scenario and you can see that we are well within the annual application rates for heavy metal approved by EPA for sewage sludge. The Canadian regulations also treat any guaranteed analysis of a hazardous substance as both a maximum and a minimum so you could have a product "stop saled" for an overage in a hazardous component. Since most domestic manufacturers of micronutrient materials market products in Canada, these regulations will become the de facto regulations in the United States.

Although we may be perfectly correct in our assertion that such products offer no threat to the environment, we still need to exercise a little common sense in the selection of by-products or waste products as fertilizer sources. Some manufacturers or their customers may not wish to produce or market a product that has certain high profile hazards such as lead or cadmium listed on the MSDS. These manufacturers would need to closely monitor the unwanted hazardous components in their raw materials to ensure that they are below the mandatory reporting levels. Some manufacturers may not wish to subject themselves to the SARA 313 reporting requirements for certain heavy metals. The de minimus level for SARA reporting is 1% of the hazardous material component. (0.1% for a known carcinogen.)

As pointed out in Mortvedt's paper, there are many waste products that can be utilized in fertilizer. Unfortunately many of these products which would be excellent micronutrient sources are also classified as hazardous wastes under RCRA. Although one of the expressed aims of the Resource Conservation and Recovery Act when it was first proposed was to encourage recycling, the actual effect has been to discourage the use of characteristic wastes because of the burdensome compliance strictures imposed by EPA. Most fertilizer manufacturers have relinquished their RCRA permits because of the high cost of complying with the RCRA operating regulations. Consequently products classified as hazardous wastes are not even considered as a source material.

Fortunately EPA has belatedly come to realize this. In April 1994, EPA circulated a report entitled *Reengineering RCRA for Recycling* which was produced by their "Defining of Solid Waste Task Force". Among the proposals presented in this report was one which would allow a special permit for a particular waste such as a waste pile which contained recoverable amounts of a heavy metal without requiring the generator of the waste or the recycler to obtain a RCRA permit. This would substantially reduce the paperwork and compliance hassles involved in obtaining and maintaining a RCRA permit. I believe there is enough interest in simplifying these procedures that the next rewrite of the RCRA legislation will do more to encourage recycling.

Some state environmental agencies are already using their authority to reclassify some products previously considered wastes into a non waste category based on economic value. I would encourage all of you to let your congressmen know your feelings on beneficial recycling. I believe it is an environmentally sound policy to encourage recycling rather than cause problems for future generatons by dumping more and more hazardous materials into landfills.

TABLE I

RCRA METALS

METAL	**REGULATORY LEVEL (mg/l) TCLP**
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	.02
Selenium	1.0
Silver	5.0

TABLE II

EXCEPTIONAL QUALITY SLUDGE
PER EPA"S 503 REGULATIONS

Pollutant	Monthly Average Concentrations Cannot Exceed Milligrams Per Kilogram*	Annual Pollutant Loading Rate (Kilograms Per Hectare Per 365 Day Period)
Arsenic	41	2.0
Cadmium	39	1.9
Chromium	1,200	150.0
Copper	1,500	75.0
Lead	300	15.0
Mercury	17	.85
Molybdenum	18	.90
Nickel	420	21.0
Selenium	36	5.0
Zinc	2,800	140.0

*Dry weight basis

Product dried sufficiently to meet Class A pathogen reduction and vector attraction reduction.

EXHIBIT I

Use 20% Zn Granular Product as ingredient to blend a 5-20-20- with 2% zinc. Application rate 500 pounds per acre.
Analysis of 20% zinc granular is:

20% Zn
2 Pb
0.1 Cd

Metal	Pounds/Acre Applied	Allowable Yearly Loading Rate (Pounds/Acre)
Zn	10	125.0
Pb	1	13.3
Cd	.05	1.7

Phosphogypsum as a Nutrient

Jack E. Rechcigl
University of Florida

Phosphogypsum ($CaSO_4$), a by-product of phosphoric acid production from rock phosphate is a potential source of calcium and sulfur for plants, as well as an ameliorant for alkaline and sodic soils. Phosphogypsum production worldwide exceeds 150 million Mg annually, with only about 4 percent being used in agriculture and industry and the rest being dumped into the ocean or stock piled as a waste. Florida leads in the production of phosphogypsum in the United States with an annual production of 33 million Mg and about 600 million Mg in stacks, and a projection a 1 billion Mg by the year 2000. This paper will discuss the various agronomic uses of phosphogypsum, (i.e. source of nutrients for plants, conditioner for sodic soils, hard-setting clay soils and subsoil hardpans, and the acidifying benefits on high pH soils to help alleviate micronutrient deficiencies). This paper will also discuss any potential environmental hazards to be concerned with from using phosphogypsum in agriculture.

Introduction

Gypsum ($CaSO_4xH_2O$) is available for agricultural use either as mined gypsum or as a chemical byproduct. Gypsum byproducts are produced in phosphoric, hydrofluoric, and citric acid production and in pollution control systems, such as in the neutralization of waste sulfuric acid and in flue-gas desulfurization. Phosphogypsum is the term used for the gypsum byproduct of wet-acid production of phosphoric acid from rock phosphate. It is essentially hydrated $CaSO_4$ with small proportions of P, F, Si, Fe, Al, several plant micronutrients, heavy metals, and radionucleides as impurities. Among the gypsum by products, only phosphogypsum is of worldwide importance in quantity and distribution.

Rock phosphate deposits are found throughout the world, and on these deposits the phosphoric acid industries are built. Countries with no natural phosphate deposits import the rock to produce phosphoric acid for their industry and agriculture. Therefore, the production of byproduct phosphogypsum is more widely distributed around the world than the natural deposits of rock phosphate. In fact there are over 150 million Mg of phosphogypsum accumulating annually worldwide, most of which is stacked in piles as waste material. By product phosphogypsum has a wide variety of uses throughout the world. Such uses include using phosphogypsum for road bed and embankment materials, wall board production, concrete production, animal feed supplement, soil amendment, and use as a fertilizer. This paper will concentrate on the advantages of using phosphogypsum in crop production.

Importance of Sulfur for Crop Production

Sulfur is one of the essential nutrients required for crop production. In general, plants contain as much S as P, the usual range being from 0.2 to 0.5% on a dry-weight basis. Sulfur ranks in importance with N as a constituent of the amino acids cysteine, cystine, and methionine in proteins that account for 90% of S in plants. It is also involved in the formation of oil in crops such as peanut *[Arachis hypogaea L.), soybean (Glycine max (L.) Merr.], flax (Linum usitissimum), and rapeseed (Brassica campestries).*

In the past three decades, S deficiencies have been reported with increasing frequency throughout the world. The reasons given for the increasing S deficiencies worldwide are (a) the shift from low-analysis to high-analysis fertilizers containing little or no S, (b) use of high-yielding crop varieties that remove greater amounts of S from the soil, (c) reduced industrial S emission into the atmosphere due to pollution-control measures and decreased use of high-S fossil fuels, (d) decreased use of S in pesticides, and (e) declining S reserves in soil due to erosion, leaching, and crop removal. Increased consumption of S-free, high-analysis fertilizers is seen as the most important reason for the increasing S deficiency worldwide.

Importance of Calcium in Crop Production

Calcium with concentration ranging from 0.2 to 1.0% in plant tissue, is also essential to plant life. Calcium deficiency manifests itself in the failure of terminal buds and apical tips of roots to develop. Also, lack of Ca results in general breakdown of membrane structures, with resultant loss in retention of cellular diffusible compounds. Disorders in the storage tissues of fruits and vegetables frequently indicate Ca deficiency.

The need for Ca by plants may be readily supplied by liming materials such as calcitic and dolomitic limestone. However, lime application in large amounts on certain soils could be detrimental to plant growth. Kamprath (1971), in a review of the effect of lime on Oxisols and Ultisols, reported that lime application that raised the soil pH to 7 resulted in reduced rate of water infiltration, reduced availability of P, B, Mn, and Zn, and reduced growth of sudangrass (Sorghum vulgare var. sudanse L.), corn (Zea mays L.) and soybean. Therefore, for certain soils that need amelioration using large amounts of Ca to support commercially variable crop yields, or for crops that need large amount of readily soluble source of Ca such as peanut, a source other than lime may be necessary.

Thus, with increasing S deficiencies worldwide and the need for a Ca source other than the liming materials, phosphogypsum deserves serious consideration for agricultural applications that traditionally use mined gypsum.

Cereal crops

It has been well documented that cereal crops will respond to S application when grown on soils deficient in S. Crops grown on soils which are low in organic matter, fine loamy to coarse textured, moderately — well to well drained soils with extractable soil — S of less than 7 kg SO_4—S ha-1 in the surface horizon tend to respond well to sulfur addition.

Studies conducted in Florida, U.S.A. have shown the addition of 1.7 to 2.2 Mg phosphogypsum ha—1 to increase green corn yields by as much as 107%. Other studies conducted in North Carolina, U.S.A. have shown corn response to gypsum application to be dependent upon the rate of N. At 56 or 112 kg N ha-1 increased grain yield and N content of grain.

Studies conducted by the International Fertilizer Development Center in Togo, West Africa have also demonstrated phosphogypsum addition (10 to 50 kg S ha-1) to increase corn grain yields by 44 to 77% over control plots. Similar results have also been obtained in Iraq.

Oates and Kamprath (1985) found that gypsum was as effective as ammonium sulfate as a source of S for winter wheat (Triticum aestivum L.). Plants responded to gypsum at rates from 22 to 90 kg S ha-1 where nonfertilized plants had S concentrations of 0.6 g kg-1 of dry matter and an N:S ratio of 21:1. Baird and Kamprath (1980) suggested that improved efficiency of S uptake by winter wheat from applied gypsum should occur on sandy soils by applying gypsum as a topdressing in early spring. In Bangladesh, Mazid (1986) reported that wheat yields from 1042 fertilization trials increased by an average of 21% due to gypsum applied at the rate of 20 kg S ha-1.

Results from demonstration trials on the effect of 124 kg gypsum (16% S) ha-1 on rice (Oryza sativa L.) in Bangladesh showed that 97% of 3,368 demonstration sites responded to gypsum (Mazid, 1986). Rice yields in gypsum-treated sites increased 19 to 41% over that of the recommended NPK-fertilized plots without gypsum. Crop responses to gypsum occurred mainly in calcareous and continuously submerged soils and were more profitable in the monsoon season than in the dry season. Studies in Indonesia found that ammonium sulfate, potassium sulfate, elemental S, and gypsum were equally effective as a source of S for rice (Momuat et al., 1983). Chien it al. (1987), in a greenhouse study, demonstrated that response of rice to gypsum was not dependent on the method of application. Sulfur uptake and grain yield were not different whether gypsum was broadcast, incorporated, or placed deep into the soil.

Grain legumes

Peanuts possess a unique nutritional habit in that supplemental Ca must be applied to the "peg", a modified stem that penetrates the soil surface to form the pod or nut. Numerous experiments have shown that supplemental Ca applied at flowering improved yield and quality of large-seeded peanuts. The role of Ca in reducing pod rot incidence in peanut is also well known. Walker and Csinos (1980) demonstrated that increasing rates of gypsum from 0.56 to 1.68 Mg ha-1 resulted in corresponding reduction in pod rot in five peanut cultivars.

A early as 1945, Colwell and Brady (1945) have established the superiority of gypsum over limestone in supplying the Ca requirements of peanut. Since then, the peanut-producing belt of the southeastern United States has used fine-ground (anhydride) mined gypsum, as the principal Ca source for peanut, broadcast at a rate of 0.5 to 1.0 mg ha-1 at first flowering when Mehlich I extractable soil Ca is <560 kg ha-1.

Sullivan et al. (1974) showed that application of dolomitic limestone on peanut, based on soil test, increased soil pH and soil Ca levels but did not improve seed quality and yield. On the other hand, gypsum at 0.673 Mg ha-1 reduced soil pH and the detrimental effects of K on fruit yield and quality, improved seed germination, seedling survival and vigor, and increased yield and improved seed quality. Daughtry and Cox (1974) found that three commercial gypsum materials, namely; fine-ground and granular anhydride gypsum and phosphogypsum supplied at the rate of 0.76 Mg CaSO4 ha-1 at flowering, produced no difference in the yield of Florigiant peanut. Hallock and Allison (1980) used similar commercially-formulated fined-ground (Bagged LP) and granulated (420 LP Bulk) anhydride gypsum, and granulated phosphogypsum (Tg Gypsum) as source of Ca for Virginia-type peanuts at the rate of 0.605 Mg ha-1. After two years of testing (1977 and 1978), the results indicated that, in general, granulated phosphogypsum and mined gypsum were as effective as fined-ground gypsum for supplemental Ca for peanuts. When fruit matured under very dry conditions, granulated phosphogypsum and fined-ground mined gypsum were superior over granulated mined gypsum. Gascho and Alva (1990), used seven gypsum materials including phosphogypsum as a source of Ca for Florunner peanuts. They concluded that no other source of gypsum exceeded phosphogypsum in solubility, or in its beneficial effects on peanut grade and yield when broadcast at the rate of 224 kg Ca ha-1 at first bloom.

In Brazil, Vitti et al. (1986) reported that application of 0.1 Mg ha-1 of phosphogypsum to soybean on Oxisol increased grain yield by as much as 43% and in Ultisol by 37%. At 0.25 Mg ha-1, phosphogypsum increased grain yield of beans (Phaseolus vulgaris L.) by 13% in Ultisol and 54% in Oxisol soil. Phosphogypsum rates used were very low so that the positive responses of the crops could be attributed more to S or Ca as nutrients than to the ameliorative effect of phosphogypsum on subsoil acidity.

Sugarcane

Golden (1983) reported that the application of phosphogypsum at 2.24 Mg ha-1 to sugarcane (Saccharum officinarum L.) in Louisiana increased stubble cane yield. Breithaupt (1989), using both phosphogypsum and fluorogypsum on sugarcane at rates of 2.24 to 22.40 Mg ha-1, reported significant increases in cane and sugar yields in treated plots over the control in both plant cane and first year stubble harvests. Both gypsum byproducts were equally effective in increasing both cane and sugar yields.

Fruits and vegetables

In Florida, phosphogypsum up to 2.24 Mg ha-1 applied to different varieties of citrus (Citrus sinensis) increased juice brix and reduced juice titratable acidity. It did not, however, increase fruit yield (Myhre et al., 1990). In Brazil, pineapple [Ananas comosus (L.) Merill, cv. Smooth Cayene] fertilized with phosphogypsum in combination with KC1 as a substitute for K2SO4. Potassium sulfate-fertilized fruits, however, had better fruit juice quality than those fertilized with KC1 alone or in combination with phosphogypsum. Use of raw phosphogypsum at 1.68 and 2.24 Mg ha-1 on various vegetable crops in 1986 in Florida increased the yields of tomatoes (Lycopersicon esculentum Mill) by 6%, potatoes (Solanum tuberosum L.) by 19%, and watermelons (Citrullus vulgaris) by 49%. Residuals from phosphogypsum applied in 1986 at 2.24 Mg ha-1 also increased the yields of potatoes by 22% and cantaloupes (Cucumis melo) by 42% with more number of fruits weighing 1.0 kg or more each. Pelleted phosphogypsum supplied to the 1987 crop did not increase the yields of potato and bell pepper (Capsicum annuum). The phosphogypsum pellets remained intact but soft, indicating only partial dissolution.

Forage crops

Thomas et al. (1951) demonstrated conclusively that S deficiency limits non-protein N utilization in purified diets for ruminants, and that SO4-S as sole source of S can correct the deficiency. Hume and Bird (1970) had shown that an intake of 1.9 g S per day by sheep produced the maximum protein production in the rumen microorganisms. Bray and Hemsley (1969) showed that S supplement to the diet increased both crude fiber digestion and S and N retention by sheep. Application of 86 kg S ha-1 using ammonium sulfate to bahiagrass (Paspalum notatum Flugge) increased dry matter yield by 25%, crude protein by 1.2%, and digestibility by 3 to 4% 30 days after application (Rechcigl et al., 1989). In a larger scale, studies in Ireland (Murphy et al., 1983) showed that cattle that grazed on S-fertilized pastures could gain up to 29% more weight than those grazing on S-deficient fields. Also, for any given daily liveweight gain, S-treated area had 21% more stock-carrying capacity the first year and 19% more the second year than the untreated pasture. These studies point not only to the need for S fertilization of forage crops for yield but also to the need to achieve a desirable range of N:S ratios to assure better feeding quality forage.

In plant protein, the N:S ratio is about 15:1 and remains fairly constant. If either S or N is limiting, protein synthesis is restricted, but the protein already synthesized will have a N:S ratio of about 15:1. Excess N relative to S supply accumulates as NO3-N, amides, and amino acids. Excess S leads to SO4-S accumulation (Stewart and Porter, 1969). Thus the wide variation in N:S ratios.

Sulfur fertilization of forage crops almost invariably results in reduced N:S ratio in plant tissue. Lancaster et al. (1971) reported that application of S at 40 mg kg-1 of soil in the form of Na2SO4 reduced N:S ratio from 32 to 9 for orchardgrass (Dactylis glomerata L.); 45 to 19 and 72 to 14 for first and second clippings, respectively, of sudangrass; 36 to 5 for ryegrass (Lolium multiflorum L.); 27 to 8 for alfalfa (Medicago sativa L.); and 33 to 16 for clover (Trifolium repens L.). On the other hand, in an 8-year field experiment using bermudagrass [Cynodon dactylon (L.) Pers], Woodhouse (1969) had shown that despite S fertilization excessive N application could produce a forage crop with N:S ratio in excess of 60:1.

In North Carolina, use of mined gypsum applied annually on coastal bermudagrass at the rates of 28 and 56 kg S ha-1 applied annually increased forage yields in 7 out of 8 years of data collection (Woodhouse, 1969). In Louisiana, Eichhorn et al. (1990) reported that annual application of 108 kg S ha-1, using gypsum, had increased bermudagrass yield by 16% over a 4-year period, with the highest increase (29%) occurring in the fourth year. Digestible dry matter also increased by 14.5% over the same period. In Florida, Mitchell and Blue (1989) conducted a 6-year study to evaluate the effect of gypsum applied annually on Pensacola bahiagrass at 200 and 400 N kg ha-1. They reported that a low N, gypsum application did not increase dry matter yield until the fourth year, with maximum yields thereafter predicted at an annual S application between 27 and 33 kg S ha-1. At high N, 10 kg S ha-1 increased dry matter yield in the second year. By the fifth and sixth years, maximum dry matter yield was predicted at an annual rate of 40 to 51 kg S ha-1. Results also showed that S fertilization enhanced N recovery. Maximum relative forage yield was obtained at a concentration of 1.61 g S kg-1 dry matter. In a one-year study in Oklahoma, application of gypsum at the rate of 64 S kg ha-1 decreased N:S ratio of bermudagrass forage from 11.6:1 to 7.2:1 but did not increase yield, N uptake, or improve N efficiency (Westerman et al., 1983).

To date very few studies have been conducted on the use of phosphogypsum on forage crops.

Paulino and Malvolta (1989) used phosphogypsum on andropogon grass (Andropogon gayanus cv. Planaltina) grown in pot with soil taken from a Brazilian Cerrado site. Results showed that phosphogypsum, in the absence of lime, increased regrowth dry matter yield linearly up to the maximum rate of 120 kg S ha-1 used in the study. Maximum protein content was attained at 63 kg S or 380 kg phosphogypsum ha-1. Lime had a significant negative effect on andropogon grass. Mullins and Mitchell (1990) used phosphogypsum as a source of S at the rates of 11 to 90 kg S ha-1 on wheat cut for forage in Alabama. Average increases in forage yield over a 3-year period ranged from 5.4 to 9.3% for two soil series. Comparison between mined gypsum and phosphogypsum showed no difference in forage yield of wheat. Phosphogypsum applied during fall or spring had no residual effect on yield of millet [Setaria italica (L.) Beauv] or sudangrass planted for summer forage after the winter wheat crop. In Florida, use of fresh phosphogypsum as a source of Ca applied at 2.24 to 4.48 ton ha-1 reduced soil pH and forage yield of ryegrass to levels below those of the control. Fresh phosphogypsum can be very acidic with pH a little over 2. A 3-year study (Rechcigl and Alcordo, 1992) evaluated phosphogypsum as a source of S and Ca for bahiagrass and ryegrass, without and with 1% dolomite or calcium carbonate needed to bring phosphogypsum pH (1:1) to 5.5. Annual rates of 0.2, 0.4, and 1.0 Mg ha-1 are compared to single phosphogypsum application rates of 2.0 and 4.0 Mg ha-1. Results showed that phosphogypsum, with or without lime, increased the two-year total forage dry matter yields of bahiagrass by as much as 28% at 0.2 to 0.4 Mg phosphogypsum ha-1. Phosphogypsum, across phosphogypsum rates, with dolomite gave the highest increase in dry matter yield with 12% over the control. Application of phosphogypsum or gypsum has been shown to deplete Mg at the surface horizon (Reeve and Sumner, 1972).

Crop Response to Gypsum and Phosphogypsum on Acid Soils

Failure of plant roots to grow into and proliferate at deeper soil horizons in acid soils due to A1 toxicity limits their capacity to take up both plant nutrients and soil moisture. Highly weathered soils such as the Oxisols and Ultisols, whose mineralogy is normally dominated by 1:1 type clay and oxides and hydrous oxides of A1 and Fe, not only retain very little moisture in the surface horizons after a rain, but also dry out very quickly during short periods of rainless days. Wolf (1975) reported that in the Cerradoes of Central Brazil corn crops can wilt after only 6 days without rain even during the wet season.

Ritchey et al. (1980) reported that gypsum contained in ordinary superphosphate (OSP) increased subsoil pH, decreased A1 saturation, and increased Ca and Mg status. Roots of corn plants fertilized with OSP reached to a depth of 120 cm, while those fertilized with triple superphosphate (TSP) reached a depth of only 45 cm and wilted after 2 weeks with no rain. Pavan et al. (1984), using undisturbed profiled of Oxisols, reported that application of gypsum reduced the level of exchangeable Al and increased Ca throughout the 100-cm profile depth. Application of CaCO3 affected only the upper 20 cm of the incorporated to a depth of 15 cm increased soybean grain yield by 25% in the second year and corn silage yield by 35% in the third year. Improvements in yield over time as a result of gypsum paralleled its progressive movement into the subsoil with subsequent decrease in exchangeable Al (Hammel et al., 1985). Sumner et al. (1986), based on a four-year study on the effect of deep liming and surface application of gypsum on alfalfa by 25%. It reduced exchangeable A1 and A1 saturation and increased Ca throughout the 100-cm depth. Farina and Channon (1988) reported that surface-applied gypsum at 10 Mg ha-1 resulted in a cumulative grain yield of 3.4 Mg ha-1 after four cropping seasons. Progressive reduction in the level of exchangeable A1 was accompanied by increased subsoil Ca, Mg, and SO4-S. Water pH increased markedly in the zone of maximum SO4-sorption/precipitation. Effects of gypsum on subsoil root development were striking by the fourth season. However this is contrary to the alfalfa studies of Rechcigl et al., 1987 and 1988a.

Studies on the use of phosphogypsum as an ameliorant for acid soils in Brazil were summarized by Shainberg et al. (1989) and Alcordo and Rechcigl (1993). Rates ranging from 0.5 to 6.0 Mg ha-1 of phosphogypsum significantly increased the yields of apples (Malus domestica), beans (Phaseolus vulgaris), coffee, rice, wheat, and corn. Sumner et al. (1990), evaluated gypsum and phosphogypsum applied at 5 to 10 Mg ha-1 incorporated into the soil in several field experiments on a range of soils in southeastern United States. The results indicate that there were no differences between the two CaSO4-sources based on crop responses and soil reactions. Highly significant and economically profitable yield responses were obtained for alfalfa, corn, soybean, cotton (Gossypium hirsutum L.), and peaches (Prunus persica L.). Gypsum and phosphogypsum application enhanced root penetration and proliferation in the subsoil, where previous conditions often prevented root growth.

AMERLIORANT FOR SODIC SOILS

Characteristics of Sodic Soils

In regions of the world where evapotranspiration exceeds rainfall, basic salts and carbonates move upward in the soil profile from the water table instead of downward as occurs in regions of acid soils. Rain water with its dissolved salts adds to salt accumulation in the upper horizon. Irrigation, while often necessary for crop production under arid or semi-arid conditions, can contribute to the build-up of salts in these soils, especially when the quality of irrigation water is poor. Soils containing both soluble salts and exchangeable Na to levels which interfere with the growth of most crops are classified as saline or sodic soils.

The most characteristic physical property of sodic soils is that they are highly dispersive due to Na ions in the exchange complex of the cooloidal fraction, particularly the silicate clays. When placed in water of low salt concentration, aggregates from these soils imbibe water until the soil deflocculates into individual soil particles (Russell, 1973). The dispersed soil particles move down the soil profile with the water clogging the macro and micro pores to such extents that they reduce or even completely stop water infiltration through the profile (McIntyre, 1958). Upon drying, hard crusts develop at the surface which make seedlings emergence difficult. Poor hydraulic conductivity and surface crusting are the two major problems that need to be ameliorated to improve sodic soils for crop production.

Use of Gypsum and Phosphogypsum on Sodic Soils

Historically, mined gypsum has been used world-wide to reclaim or ameliorate sodic soils because of its abundance and low cost. The process of reclamation or amelioration of sodic soils involves (1) the replacement of Na by Ca ions in the exchange complex and (2) leaching excess Na out of the root zone. Their process requires (1) the maintenance of a desired exchangeable Na fraction in the exchange complex and (2) the supply of electrolytes of a desired composition and ionic strength to the solution phase without increasing its alkalinity. The process requires the dissolution of gypsum, solute and water movement, and exchange of Na in the exchange complex with Ca ions in the solution phase.

The use of gypsum to counteract the adverse effects of surface crusts on seedling emergence has been widely recognized (Cary and Evans, 1974). In Australia, application of 4.48 and 17.9 Mg gypsum ha-1 to a sodic soil planted with lowland rice increased the Ca:Na ratio of both soluble and exchangeable cations. Between 1963 and 1965, an estimated 44,500 ha of allow soils were treated with gypsum to improve dryland wheat yields in the Wimmera and Southern Mallee districts of Victoria, Australia (Sims and Rooney, 1965).

Phosphogypsum has been effectively used in the USSR to reclaim solonetz and solonitizic soils, with 3.2 million Mg used in 1988 for this purpose. Its use is expected to reach 19.2 million Mg by the year 2000 (Novikov et al., 1990). Mishra (1980), summarizing phosphogypsum research in India, which began in 1973, concluded that up to 32 Mg ha-1 of Indian phosphogypsum, can be used safely for reclamation of sodic soils, despite the high F content. Oster (1980), assuming a ten-fold solubility of phosphogypsum over mined gypsum, demonstrated that rate and frequency of surface application would be different for phosphogypsum than for mined gypsum at a given electrolyte concentration and rate of water application.

Bulk Carrier For Micronutrients and Low-Analysis Fertilizers

Micronutrients B, Cu, Mn, Zn, and Fe are applied to soils to meet crop needs in relatively small amounts. Obtaining uniform distribution of small rates is difficult. This difficulty is surmounted by bulk-blending micronutrients with granular fertilizers. From 1950 to 1980, the market share of bulk-blended fertilizers (Harre and White, 1985). It is expected to continue to increase as finer delineation of the fertility status of agricultural lands is achieved requiring more custom-analysis blended fertilizers. Bulk-blended fertilizers use high-analysis fertilizers such as urea for N, which for clay-coated agricultural grade is 46% N, triple superphosphate with 20% P, and potassium chloride with 48% K. Such environmental considerations as nitrates in drinking water eutrophication of surface waters, due to use of locally-blended low-analysis fertilizers applied more frequently than at present. Phosphogypsum, where readily available, provides a potential bulk carrier for micronutrients and low analysis fertilizer formulations. Phosphogypsum disked into the top 10 cm of soil at a rate of 112 Mg ha-1 had no adverse affect on yields of corn, wheat, or soybean (Mays and Mortvedt, 1986). Pelletized phosphogypsum, enriched with micro and macronutrients, has shown promise with urea and sulfate of potash magnesia (Hunter 1989) as pelletizing agents. Also, phosphogypsum mixed with urea at 2.3 times the weight of the latter has been found to reduce ammonia loss by 85% (Bayrakli, 1990).

CONCLUSIONS

Based on the review of the literature, phosphogypsum appears to be good as mined gypsum as a source of S and Ca for crops (Alcordo and Rechcigl, 1993). In some cases surface application, appears to ameliorate subsoil A1 toxicity and acidity in shorter time periods than lime. Phosphogypsum may prove to be superior to mined gypsum as an ameliorant for A1 toxicity and as a conditioner for sodic soils, hard-setting heavy clay soils, and subsoil hardpans to improve saturated hydralic conductivity, surface and subsoil aggregation, and general structural development. Fluorides, which are not present in mined gypsum, help to detoxify A1, and acid impurities can increase the fluocculating and aggregating power of soil- and phosphogypsum-A1 and -Fe, if properly exploited.

Also, phosphogypsum, where it is readily accessible, is a potential bulk carrier for micronutrients and low-analysis fertilizers. Increasing environmental demands to prevent contamination of ground water with nitrates and minimize applied N and P losses which promote rapid eutrophication of surface waters, may require the use of low analysis fertilizers in commercial agriculture as they are now commonly used in recreational and residential lawns and gardens.

Radionuclides, heavy metal impurities, and other pollutants in the order of magnitudes found in Florida phosphogypsum do not appear to constitute environmental hazards to surficial ground water, ambient atmosphere, crop tissue, or soil at rates normally used in agriculture (Alcordo and Rechcigl, 1995). Based on currently available information, phosphogypsum appears to be environmentally safe as a source of S and Ca in crops and for other described uses in agriculture.

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REFERENCES

Alcordo, I. S. and Rechcigl, J. E. (1993). Phosphogypsum use in agriculture: A review. *Advances in Agronomy Academic Press,* 49:55-118.

Alcordo, I. S. and Rechcigl, J. E. (1995). *Phosphogypsum and other by-product gypsums.* 365-425. In: J. E. Rechcigl (ed.). *Soil Amendments and Environmental Quality.* Lewis Publishers, Boca Raton, FL.

Baird, J. V., and Kamprath, E. J. (1980). *Agricultural use of phosphogypsum on North Carolina crops.* 133-150. Proc. Int. Symp. on Phosphogypsum. Pub. No. 01-001-017. FL. Inst. Phos. Res., Bartow, FL.

Bayrakli, F. (1990). Ammonia volatilization losses from different fertilizers and effect of several urease inhibitors, CaCl2 and phosphogypsum on losses from urea. *Fert Res.* 23:147-150. 1990.

Bray, A. C., and Hemsley, J. A. (1969). Sulphur metabolism of sheep. IV. The effect of a varied dietary sulphur content on some body fluid sulphate levels and on the utilization of urea-supplemented roughage by sheep. *Aust. J. Agric. Res.* 20:759-773.

Breithaupt, J. A. (1989). *Effect of by-product gypsum on yield and nutrient content at sugarcane and soil properties.* M. S. Thesis, Louisiana State Univ. Baton Rouge, LA.

Chien, S. H., Hellums, D. T., and Henao, J. 1987. Greenhouse evaluation of elemental sulfur and gypsum for flooded rice. Soil Sci. Soc. Am. J. 51:120-123.

Colwell, W. E., and Brady, NC (1945). The effect of calcium on yield and quality of large seeded type peanuts. *J. Am. Soc. Agron.* 37:413-428.

Daughtry, J. A., and Cox, F. R. (1974). Effect of calcium source, rate, and time of application on soil calcium level and yield of peanuts (Arachis hypogaea L.). *Peanut Sci.* 1:68-73.

Eichhorn, Jr., M. M., Feagley, S. E., and Nelson, B. D. (1990). Effects of sulfur fertilization on Coastal bermudagrass grown on Coastal Plain soil. *Proc. Am. Forage and Grassl. Conf.*, Blacksburg, VA.

Farina, M. P. W., and Channon, P. (1988). Acid subsoil amelioration II: Gypsum effects on growth and subsoil chemical properties. *Soil Sci. Soc. Am. J.* 52:175-180.

Gascho, G. J., and Alva, A. K. (1990). Beneficial effects of gypsum for peanut. p. 376-393. Proc. 3rd. *Int. Symp. on Phosphogypsum.* Pub. No. 01-060-083. Fl. Inst. Phos. Res., Bartow, FL.

Golden, L. E. (1982). Results from by-product gypsum outfield tests with sugarcane, 1975-1982. *Report of Projects,* Dept. of Agron., La. Agr. Exp. Stn., Baton Rouge, LA.

Hallock, D. L., and Allison, A. H. (1980). Effect of three Ca sources applied on peanuts. In Productivity and seed quality. *Peanut Sci.* 7:19-25.

Hammel, J. E., Sumner, M. E., and Shahandeh, H. (1985). Effect of physical and chemical profile modification on soybean and corn production. *Soil Sci. Soc. Am. J.* 49:1508-1511.

Harre, E. A., and White, W. C. (1985). Fertilizer market profile. p.1-24. In O. P. Engelstad (ed. *Fertilizer Technology and Use.* 3rd ed. SSSA. Madison, WI.

Hume, I. D., and Bird, P. R. (1970). Synthesis of microbial protein in the rumen: IV. The influence of the level and form of dietary sulphur. *Aust. J. Agric. Res* 21:315-322.

Hunter, A. H. (1989). *Use of phosphogypsum fortified with other selected essential elements as a soil amendment on low cation exchange soils.* Pub. No. 01-034-081. Fl. Inst. Phos. Res., Bartow, FL.

Kamprath, E. J. (1971). Potential detrimental effects from liming highly weathered soils to neutrality. *Soil Crop Sci. Soc. Fla. Proc.* 31:200-203.

Lancaster, D. L., Jones, M. B., Oh, J. H., and Ruckman, J. E. (1971). Effect of sulphur fertilization of forage species on yield, chemical composition, and in vitro rumen microbial activity of sheep. *Agron. J.* 63:621-623.

Mays, D. A., and Mortvedt, J. J. (1986). Crop Response to Soil Applications of Phosphogypsum. *J. Environ. Qual.* 15:78-81.

Mazid, S. A. (1986). The response of major crops to sulphur in Int. Symp. on Sulphur in Agric. Soils. *The Bangladesh Agric. Res. Council and The Sulfur Inst.* Dhaka, Bangladesh.

McIntyre, D. S. (1958). Permeability measurements of soil crusts formed by raindrop impact. *Soil Sci.* 5:185-189.

Mishra, U. N. (1980). Use of phosphogypsum in reclamation of sodic soils in India. *Proc. Int. Symp. on Phosphogypsum.* p. 223-241. Pub No. 01-001-017. Fl. Inst. Phos. Res., Bartow, FL.

Mitchell, C. C., Jr., and Blue, W. G. (1989). Bahiagrass response to sulfur on an Aeric Haplaquod. *Agron. J.* 81:53-57.

Momuat, E. O. , Mamril, C. P., Umar, A. P., and Momuat, C. J. S. (1983). *Sulphur deficiency and how to cue it in South Sulawesi.* p. 295-307. In The role of research results of rice and upland food crops in agricultural development. *Central Res. Inst. for Food Crops.* Bogor, Indonesia.

Mullins, G. L., and Mitchell, Jr., C. C. (1990). Use of phosphogypsum to increase yield and quality of annual forages. Pub. No. 01-048-084. *Fl. Inst. Phos. Res.*, Bartow, FL.

Murphy, M. D., Brogan, J. C., and Noonan, D. G. (1983). Sulfur fertilization of pasture improves cattle performance. *Sulphur in Agric.* 7:2-6.

Myhre, D. L., Martin, H. W., and Nemec, S. (1990). Yield 226Ra concentration, and juice quality of oranges in groves treated with phosphogypsum and mined gypsum. p. 11-40. *Proc. 3rd. Int. Symp. on Phosphogypsum* (Supplement). Pub. No. 01-060-083. Fl. Phos. Res. Inst., Bartow, FL.

Novikov, A. A., Klassen, P. V., and Evenchik, S. D. (1990). The status and trends of phosphogypsum utilization in the USSR. p. 594-601. Proc. 3rd. *Int. Symp. on Phosphogypsum.* Pub. No. 01-060-083. Fl. Inst. Phos. Res., Bartow, FL.

Oates, K. M., and Kamprath, E. J. (1985). Sulfur fertilization of winter wheat grown on deep sandy soils. *Soil Sci. Soc. Am. J.* 49:925-927.

Oster, J. D. (1980). Gypsum usage in irrigated agriculture. p. 133-169. *Proc. Int. Symp. on Phosphogypsum.* Pub. No. 01-001-017. Fl. Inst. Phos. Res., Bartow, FL.

Paulino, V. T., and Malavolta, E. (1989). Effect of phosphogypsum, phosphorus, and lime on Andropogon gayanus Kunth. *XVI Int. Grassl. Congr.* p. 39-40. Nice, France.

Rechcigl, J. E. (1989). Importance of sulfur fertilization of forages. *The Florida Cattleman,* April, 1989. p.52.

Rechcigl, J. E., Edmisten, K. L., Wolf, D. D., and Reneau, R. B., Jr. (1988a). Response of alfalfa grown on acid soil to different chemical amendments. *Agron. J.* 80:515-518.

Reeve, N. G., and Sumner, M. E. (1972). Amelioration of subsoil acidity in Natal Oxisols by leaching of surface-applied amendments. *Agrochemophysica* 4:1-6.

Russell, E. W. (1973). *Soils Condition and Plant Growth.* 10th ed. Longman, NY

Shainberg, I., Sumner, M. E., Miller, W. P., Farina, M. P. W., Pavan, M. A., and Fey, M. V. (1989). Use of gypsum on soils: A review. *Adv. in Soil Sci.* 9:1-111.

Sims, H. J., and Rooney, D. R. (1965). Gypsum for difficult clay wheat growing soils. *J. Dept. Agric.*, Victoria 63:401-409.

Stewart, B. A., and Porter, L. K. (1969). Nitrogen-sulfur relationships in wheat (Triticum aestivum L.), corn (Zea mays), and beans (Phaseolus vulgaris). *Agron. J.* 61:267-271.

Sullivan, G. A., Jones, G. L., and Moore, R. P. (1974). Effects of dolomitic limestone, gypsum, and potassium on yield and seed quality of peanuts. *Peanut Sci.* 1:73-77.

Sumner, M. E. (1990). Gypsum as an ameliorant for the subsoil acidity syndrome. Pub. no. 01-024-090. *Fl. Inst. Phos. Res.*, Bartow, FL.

Sumner, M. E., Radcliffe, D. E., McCray, M. and Clark, R. L. (1990). Gypsum as an ameliorant for subsoil hardpans. *Soil Technol.* 3:253-258.

Sumner, M. E., Shahandeh, H., Bouton, J., and Hammel, J. (1986). Amelioration of an acid soil profile through deep liming and surface application of gypsum. *Soil Sci. Soc. Am. J.* 50:1254-1258.

Thomas, W. E., Loosli, J. K., Williams, H. H., and Maynard, L. A. 1951. The utilization of inorganic sulfates and urea nitrogen by lambs. J. Nutr. 43:515-523.

Vitti, G. C., Ferreira, M. E., Malavolta, E. (1986). *Respostas de culturas anuais e perenes.* p. 17-43. In I Seminario sobre o uso do fosfogesso na agricultura. *EMBRAPA*, Brasilia, Brazil.

Walker, M. E., and Csinos, A. S. (1980). Effect of gypsum on yield, grade and incidence of pod rot in five peanut cultivars. *Peanut Sci.* 7:109-113.

Westerman, R. L., O'Hanlon, R. J., Fox, G. L., and Minter, D. L. (1983). Nitrogen fertilizer efficiency in bermudagrass production. *Soil Sci. Soc. Am. J.* 47:810-817.

Wolf, J. M. (1975). *Soil-water relations in Oxisols of Puerto Rico and Brazil.* p. 145-154. In E. Bornemisza and A. Alvarado (eds.) *Soil management in tropical America.* North Carolina State Univ., Raleigh, NC

Woodhouse, W. W. (1969). Long-term fertility requirements of Coastal bermudagrass. III. *Sulphur. Agron. J.* 61:705-708.

Tuesday, October 24, 1995

Session III
Moderator:

Phillip "Whit" Yelverton

International Agricultural—Policy Update

O.J. Eilertsen
EFMA

In general politicians are supposed to work for the common good of society and to care for the interest of the many, often at the expense of the few. That is their electoral base.

In agriculture policy one might ask if it is not the opposite - that the strive for the support of the few is being done at the expense of the many, the many being food consumers and tax payers, i.e. all of us.

Agricultural policy in most countries deals with attaining a series of goals which seems quite contradictory to reach at the same time. In order to attain such non compatible aims a jungle of detailed prescriptions and directives is necessary, and in addition a series of exception from those prescriptions are needed.

It would therefore be appreciated if, we during this panel discussion could raise the question why it is that agriculture may not be subject to the same market forces that we nowadays preach as the true gospel for all other activities in society.

In my presentation I will go briefly through the development of the European common agricultural policy—the CAP—and its linkage the surrounding world through the GATT. But let me first present some facts and figures on European and US agriculture in order to shed some light on the big differences, but also some similarities. From the facts and figures illustration comparing the EU 12 and the United States, we see that Europe has to feed 35% more people on an agricultural area only 1/3 of that of the United States. On this same area, Europe has three times as many farms as the United States, resulting in an average farm size in Europe which is only 1/10 of that of the United States. Remarkable is also the very large grain maize production in the US compared with EU 12 and the four times larger production of barley in Europe. The only similarity is that the two areas produce about the same quantity of meat, in the US split about equally between beef, poultry and pigs whereas in Europe pig meat constitutes about half of the production.

From the overview "30 years of CAP" the development of the common European policy of the European Union over the last three decades and in the beginning of the nineties is shortly described. The basis for this policy is article 39 of the Treaty of Rome which was signed by the six founder nations of the European Economic Community in 1957. This article describes the aim of a common European agricultural policy as follows:

- to increase agricultural productivity;
- to ensure a fair standard of living for the agricultural community;
- to stabilise markets;
- to assure availability of supplies;
- to ensure that supplies reach consumers at reasonable prices.

This has been the basis for the European Common Agricultural Policy, and these basic aims have not been changed over the last 30 to 40 years of development.

It is interesting to note that the practical development of the CAP has taken place during a period where three new member states have been added to the EU each decade until now comprising fifteen European countries compared with the original six. It goes without saying, that to establish and maintain a common policy for an area like agriculture which was so politicised within each of the member states, during a period with such a major expansion, has been a difficult task which many times has been judged not to succeed. There is a vast difference in agricultural structure and practice between the fifteen member states from Great Britain where only 2% of the active population is employed in agriculture to Greece where the agricultural employment accounts for 25%. Not to speak of the language, cultural and climatic differences between the EU member states.

Until the late eighties the main aim of the Common Agricultural Policy was to produce enough food and make Europe less dependent on food imports. A series of incentives were established for this aim, the most important of which were a high, protected European price for agricultural products, a guaranteed purchase of a surplus production at politically established intervention prices and subsidised exports of these surpluses. This led to a sizeable overproduction of the most important food products like grain, meat and milk. A major concern for the European Union was to manage these surpluses and to handle the big burden they caused on the Union's budget.

In the late eighties the European Union introduced price disincentives to curtail the production without success. Instead of reducing production, the farmers felt compelled to increase it in order to compensate for the lower prices. A new and more forceful policy was therefore called for. In 1992 the so called CAP reform was decided in order to come to grips with the overproduction and also to meet the requirements and claims presented by the international community during the GATT negotiations in the Uruguay Round.

The main aims of the CAP reform is presented in the next review. As may be seen a production curtailment and reduction of export surpluses have a central position together with sustaining the farmers' income. The main measures to achieve these aims were a drastic price reduction of approx. 30% for cereals and 15% for meat. To maintain the farmers' income a system of price compensation was introduced, not based on the production volume, but as a per ha contribution for the cultivated area. In order to achieve this compensation, the farmer had to set aside 15% of his area dedicated for the production of cereals, oilseeds or pulses. For this set aside area he receives an additional compensation per ha of set aside land. For meat and milk farmers restrictions were introduced in the form of a number of animals per ha and milk quotas, and these restrictions were again compensated in the form of a per head premium for animal stock.

As mentioned an important aim was to comply with the requirements in the Uruguay Round negotiations of GATT. For the first time agriculture was an integral part of the GATT negotiations, and a series of measures have been taken to liberate world trade also for agricultural products. The EU is obliged to reduce subsidised cereal exports and also to reduce import obstacles for agricultural products.

The experience of the CAP reform so far is summarised in the last view graph showing that the EU cereal production has come down to a level of about 160 millions tons per year, a reduction of about 20 millions tons from the highest level. Subsidised exports have been reduced, also because of increase in consumption of EU grain for animal feed on account of imported protein feedstuff. The intervention stocks have been reduced for all food products and are now at a low and manageable level. Because of the sharp increase of world market cereal prices combined with the sharp reduction of EU prices the intervention price for cereals in the EU is practically on the same level as the world market price. Finally, the CAP reform has led to a policy in full compliance with EU's obligations under the new GATT deal.

These are encouraging results of a political choice made in 1992 considered at the time both drastic, courageous, and risky. Since then we have experienced a total change of the world food supply/demand picture, with increasing demand, reduced supply, and cereal stocks reduced to an all time minimum, with strong upward effects on world cereal prices.

One might ask whether the CAP reform was not better suited to cope with the situation of the late eighties rather than to meet what now seems to emerge as the requirements toward the turn of the century i.e., to restore world food supply to meet an increasing demand. It is, of course, always more convenient to judge a policy with hindsight rather than to establish one for an unknown and uncertain future. The EU has responded to the new situation by reducing the set-aside requirements to 12% for 1994/95 and 10% for 1995/96. The farmers are thus enjoying the pleasant combination of increased production allowances, higher prices, and income compensation. Nothing could be better for the fertilizer industry.

Questions:

- Why cannot farmers accept the conditions of the market forces?

- Would a totally market oriented farming be to the detriment of

1. the farmers

2. society

Common Agricultural Policy (CAP)

European Union (EU)

- Facts and figures on agriculture
- 30 years of CAP
- CAP reform 1992
- Gatt implications
- CAP reform — experience so far

Facts and Figures on Agriculture

		EU 12	USA
Total population	Mill.	350	260
Total land area	Mill. ha	240	920
Agricultural area	Mill. ha	130	430
Arable land	Mill. ha	68	160
Production • wheat	Mill. t	86	66
• grain maize	Mill. t	31	237
• barley	Mill. t	43	10
• meat	Mill. t	31	31
Number of farms	Mill.	6	2
Average farm size	Ha	19	190
Agri employment	Mill.	7	3
Agri employment	%	6	3

30 years of CAP

Sixties (EEC 6)

- Establish common market institutions
- Improve domestic food supply
- Improve farm productivity

Seventies (EC 9)

- Attain food self-sufficiency
- Manage occuring export surpluses

Eighties (EC 12)

- Manage export surpluses
- Manage heavy burden on community budgets
- Introduce price desincentives to curtail production

Ninties (EU 15)

- Introduce a fundamental reform in view of the insufficient effects of the measures taken in the late eighties

CAP reform 1992

Aims

- Reduce production/export surpluses
- Sustain farmer income
- Improve environment through extensification Reduce farmer input costs
- Increase domestic cereal consumption
- Reduce budgetary burden
- Comply with GATT

CAP reform 1992

Main measures

Price reduction
- Cereals—30%
- Meat —15%

Set aside
- 15% for cereals, oil seeds, pulses

Quotas
- Number of animals per Ha
- Milk quotas

Income compensation
- Price compensation
- Set aside compensation
- Per head premium for animal stock

Exemptions
- Small farms (< 92 t: 20 Ha)
- Non food crops

GATT implications

Uruguay round

- Agriculture integral part of GATT
- EU subsidised cereal exports to be reduced by 21% to 23 Mill. tons by 2000/2001
- Import obstacles on food to be recalculated into tariffs, which are to be reduced by an average of 36% by 2000/2001
- Duty-free food import amounts rising from 2% to 5°/o for any product
- Non discriminatory practices—most favoured nation clauses, except for
    - Preferential agreements: GSP/Lomé
    - Customs union: EU
    - Free trade agreements: EEA and Eu rope agreement with CEE

CAP reform

Experience so far

- Cereal production down to about 160 Mill. tons, including East Germany (previously 180 million tons at the highest)
- Increase in consumption of EU grain for animal feed by 6 million tons, replacing imported feed inputs
- Reduction in intervention stocks:
    - cereals from about 30 million tons to about 10 million
    - beef from about 1.2 million tons to 100.000
- Intervention price of cereals practically equal to World market price
- Compliance with the obligations under the GATT deal

International Agricultural—Policy Update

Everett Zillinger
The Fertilizer Institute

To begin, I'd first like to thank the Fertilizer Industry Round Table for inviting me here. Any opportunity to leave Washington, D.C. or what we call Disneyland East, I jump at it.

I've been asked to give you a very brief summary of the course of the 1995 Farm Bill debate, the congressional budget battle and how its going to impact federal farm policy.

Please keep in mind that much of what I tell you this morning is going to be outdated in the next 24 hours. The full House and Senate will be taking up debate on the Republican Budget Reconciliation package and the heart of the Farm Bill, the commodity programs, will pass or fail with the votes on Budget Reconciliation.

Politically, the Farm Bill debate all year long has focused primarily on one issue — Reform vs. Status Quo. Later this week we'll have a clearer picture of which approach will win in the end.

Politically, there are really only three things that need to be answered to continue federal farm policy, they are:

1. How much federal money there is to spend to buy the farm vote?
2. Who or what kind of farmer is going to receive the money?
3. What does that farmer have to do to get the federal money?

To give you an idea of the Federal Budget trends, this is a snap shot of how much and where the money went five years ago.

During the 1990 farm bill debate, the bulk of USDA spending (50 percent) was on food stamps, the Women with Infant Children (WIC) program and other urban welfare types of programs. Farm commodity spending on the four major commodities — corn, cotton, wheat, soybeans, was just 20 percent of the total USDA budget.

Even five years ago it was easy to see politically the urban votes were carrying the rural votes. In other words, enormous amounts of federal taxpayer dollars were doled out to city residents in order that a much smaller amount of federal taxpayer dollars could be spent on rural folk.

Today, as you can see, the relationship between urban support for farm programs vs. rural support — is becoming even more lopsided. The trend is clear — food program spending, strongly supported by urban Members of Congress, is growing significantly. Today, in the 1995 farm bill debate it's about 62 percent of total USDA spending.

While farm commodity program spending, supported by dwindling numbers of farm district Congressmen, has declined to only about 18 percent of total USDA spending and is expected to decline significantly in the next seven years.

As with all things political, if you want a full understanding of where farm bill spending is headed all one needs to do is FOLLOW THE MONEY.

It's no secret that all year long federal budget cuts and the Republican Budget Reconciliation process are aiming to cut $13.4 billion from farm commodity programs.

Just about anything involved with farm programs has a federal budget impact either an outlay (a cost), or a potential budget savings. Controversial issues such as payment limits, farmer means testing, targeting of payments, CRP and ARP, Environmental or Conservation Compliance and Flexibility, all have significant federal budge impacts.

All of these issues have not been so much policy driven but budget driven throughout the year.

Here's where the politics begins:

When the Republicans won control of Congress last November, they used a now well known campaign gimmick — the Contract with America — to highlight their fiscal and conservative thinking. One of the contract promises was to pass legislation in Congress to balance the budget in seven years or by the year 2002.

When the Republicans won control of Congress, they suddenly realized that they had to deliver on their campaign gimmick, pass the contract and work to balance the budget. By doing so, this meant that farm program spending at first was to be cut by about $22 billion.

The new Chairman of the House Agriculture Committee, Rep. Pat Roberts (R– KS), practically sold his political soul to reduce the commodity program budget cuts from $22 billion to $13.4 billion over seven years. The political price was that the Republican leadership demanded that the Chairman bring real reform to federal farm policy, not just tinker with current outdated, Roosevelt era farm programs. The result was a farm bill debate focusing on two distinctly different farm bill approaches, one in the House and one in the Senate:

The House approach, known as the Freedom to Farm Act written by the aforementioned Chairman Roberts, is a politically bold and totally clean sheet approach to federal farm policy. The Freedom to Farm Act eliminates farm programs as we known them. It eliminates loan rates, target prices, deficiency payments, and the Acreage Reserve Program (ARPs). In their place, the House bill installs a single annual payment/over seven years calculated by 1990 base and yield formulas with annual budget cuts factored in.

Its critics, mainly Washington based national commodity lobby organizations, say its welfare – – giving farmers money and not asking them to do anything in return to earn it. And they're right.

Its proponents, mainly farmers, and state commodity organizations, say it does away with long outdated 1930's Roosevelt era supply control, payment strategies and mind–boggling ASCS bureaucracy. And they're right too.

The Senate approach, basically is a status quo approach, although it does have significant changes from current law. The authorless and vaguely titled "Senate Option" keeps the decades old farm commodity program structure of target prices, loan rates, and deficiency payments in place. However, it too eliminates ARPs, increases planting flexibility and reduces farm payments. It also caps the Conservation Reserve Program (CRP) and takes it to a more realistic level of about 25 million acres in seven years.

Although the Senate and House programs are vastly different — Reform vs. Status Quo — they have three important things in common, both House and Senate approaches:

1. Eliminate ARPs — no more supply control programs that take millions of acres out of production which has cost our industry more than $500 million a year over the past 15 years.
2. Ensure 100 percent planting flexibility — farmers will finally be planting for the market place, not for the Government.
3. Reduce CRP from 36.4 to 25 million or more/over seven years.

In short, where is federal farm policy headed? In the coming months watch closely the following issues and decide for yourself: 1) Reduced federal budgets, 2) Declining rural political clout — fewer farm votes, 3) Short grain ending stocks and tight supplies of grain and inputs, 4) Increasing global demand for U.S. grain and farm inputs resulting in, 5) Higher prices for U.S. commodities, food, and farm inputs.

In view of all these, I will echo all the previous speakers and say that in the short term, federal farm policy is Full Throttle. As near to fence row to fence row as possible without the Secretary of Agriculture actually advocating it.

The long term federal farm policy forecast is not so clear, but briefly my predictions are these: If the Republicans retain control of the House and Senate? A long term, five to ten year forecast you could call for: 1) drastically reduced or eliminated federal farm budgets, 2) the probable elimination of farm commodity programs altogether, 3) the probable elimination of the House Agriculture Committee, it then becoming a subcommittee to the Natural Resources Committee, and 4) the continued reduction or even elimination of the U.S. Department of Agriculture.

Overall, I believe the federal government will have a vastly declining role in influencing local planting decisions and commodity prices. However, the federal government is quickly moving toward a much expanded role in dictating a landowners farming practices and land use decisions regarding the environment. In the near future, the federal Clean Water Act, Safe Drinking Water Act, Coastal Zone Management Act, Great Lakes Initiative, Chesapeake Bay Program and possibly the 2002 Farm Bill, all will have an expanded regulatory role in dictating and controlling the actions of U.S. agriculture producers. Watch for federal programs that require farm plans or whole farm plans.

Environmentalists still want to know what the farmer is doing. USDA employees who very soon may be out of a commodity program job due to the farm bill reform are looking for more environmental paperwork and bureaucratic red tape to keep them employed. Whole Farm Plans will probably not be a part of the 1995 Farm Bill but it's a concept that USDA will try to keep alive.

To conclude, we can only speculate, if the sun is finally rising on free market federal farm policy with no supply controls or is the sun setting on traditional Roosevelt era, status quo farm programs. I believe the answer to both of these, at least for the next 24 hours, is YES.

International Agricultural—Policy Update

K.G. Soh

IFA

Introduction

Developing countries share a common denominator in that agriculture plays a predominant role in their economic activity (Table 1). According to the latest World Bank report, up to 70% of the gross domestic product could be derived from agriculture as compared to an average of 3% for the industrialized countries. Further, an even higher percentage of people in developing countries are engaged in agriculture (Table 2). Among the countries in Sub-Saharan Africa, the majority of these countries have over 70% of its population engaged in such an activity. In contrast, it is less than 10% for all industrialized countries. As such, the national policies of developing countries are often tied to their agricultural development priorities. Quite often, the success or failure of economic development is linked to their performance in the agricultural sector. While several developing countries in recent times have advanced industrially, they usually do so upon the back of the success of the agricultural sector. The agricultural sector still contains the bulk of the economically disadvantaged group. Even in the developed countries, this sector has to be nurtured with special preferential treatment. When compared with the other sectors in the national economy, agriculture is the last to be liberalized and this helps to explain why the topic of agricultural trade was finally included in the Uruguay Round of GATT negotiations that took seven long years. The first of these rounds of GATT negotiations began in 1947.

The GATT Agreement concluded at the Uruguay Round should reduce tariffs, export and internal subsidies in agriculture. The quantum of the reduction would be greater among the industrialized countries compared with the developing countries. Furthermore, industrialized countries have to implement the changes over a six-year period against ten years for the developing countries. The GATT Agreement clearly reflects the importance of the role of agriculture in the economy of the developing countries and its perceived importance to food security. Further these countries needed more time to adjust to new competition.

Agricultural Policy in Developing Asia

With the exception of several countries in East Asia and a couple of city-states, Asia remains largely an agricultural continent. Several factors had been responsible for the lack of progress to diversify. The principal factor was possibly the inability of its leaders to adapt to the new changes taking place, let alone the inability to perceive their own large internal markets. Even with the economic success of Japan, it took at least a decade or longer for some of its neighbouring countries to emulate the Japanese strategies to shed its agricultural dependency. When the great Indian leader Jawaharlal Nehru called upon his people to « Look East » - not necessarily to Japan but to their own inherent qualities - his advice was largely ignored. It took a full generation before that advice was appreciated.

In order to better understand the present agricultural policies of the two key developing countries in Asia, it would be worthwhile to review the major changes in their recent history.

China

This country paid a very high price for its refusal to adapt to the changes brought about by the Renaissance in Europe and the Industrial Age that followed. For nearly two thousand years, it possessed the largest economy that was almost truly self-sustaining. After reaching its peak of development in the mid-seventeen century, it took a quarter of millennium of bureaucratic sclerosis and internal decay, before it was able to shed the last of the long line of dynasties. This was followed by nearly forty years of civil disorder before the present government exerted full control. Tired and in tatters, the people were ready to accept new social experiment in the expectation of improving their well-being.

The first major social experiment, known as the « Great Leap Forward » of 1959-61 ended in major disaster. The effort to de-emphasize agriculture in favour of small cottage industries, resulted in a major shortfall in agricultural production. Between 40-45 million people were believed to perished in the ensuing famine. The present existence of over 1000 ABC and SSP plants is the legacy of this experiment.

The second major social experiment was the « Cultural Revolution » of 1966-70. The primary objective was ideological cleansing. The ruling members appear to suffer from paranoia that there was a drift from proletarianism to a bourgeois way of life. Education was disrupted and trained professionals were drafted to carry out rural manual work.

After the death of Mao Tse-tung in 1976, major economic reform began in earnest under Deng Xiao-ping in 1979. In agriculture, the responsibility for production reverted to individual farmers. The farmers were obliged to meet a set of quotas of produce, and thereafter, the farmers were able to sell any excess in the open market. In turn, the State would provide such inputs as fertilizers, agrochemicals, fuel and credit for machinery and so forth. The farm reform was a great success for it permitted the farmers to exercise their entrepreneurial spirit.

Deng and his planners must have realized that even with the liberation of the economy, progress would be slow if the population growth were not reined in. When exhortation produced no results, severe if not draconian, measure was enacted, resulting in the one-child family. This law, enacted in early 1980's would last a full generation to around 2007. The objective of the programme is that when the law is repealed and normal reproductive process resumes, the country would have progressed to a point which would prevent it from slipping backward. The population growth rate of China between 1985-93 was 1.4% per annum, one of the lowest among the developing countries.

With the initial agrarian reform, China was able to embark on its second attempt to industrialize. By opening its doors to foreign investment it was able to tap the vast pool of financial resources and advance technology. It also brought in new ideology for which it was not prepared. The resultant student uprising in Tiananman in 1989 slowed investment temporarily but it also provided the opportunity for the others who had missed the first wave to invest. Exports increased pace quite dramatically and are expected to reach US$ 180 bn during the current year. Two years ago, the Government tried to accelerate the industrialization programme but was met with some serious rural unrest. Since then, the Government has reaffirmed its commitment to agriculture as the backbone of the national economy for some years to come. The net effect of the recent industrialization programme is the uprooting of a very massive segment of the rural population, estimated at around 150 million who are moving to the already crowded cities to seek better opportunities. It is against this background that the basic agricultural policy of China is being formulated.

Besides the rather painful path to modernization, Chinese agriculture is also limited by available arable land. Less than 10% of the land is at present suitable for farming. Most of these areas are along the coastal belt and the banks of the three major rivers. The present industrialization programme has rapidly destroyed over around half a million hectares per year the rich agricultural land (Table 2).

The present government policy is to liberalize agricultural production and at a pace the farmers are able to absorb. Among the priority agenda pertaining to their agricultural policy are:

- Maximize production output and quality improvement.
- Develop agricultural processing centres.
- Lift the restriction on agricultural production.
- Allow provinces to disengage from price supervision at a pace each province can accommodate.
- Continued emphasis on the animal husbandry sector.
- Investment into infrastructure improvements such as water conservancy, anti-flood and anti-drought measures.
- Achieve crop production targets through subsidy and price support.
- Continued state monopoly for certain sensitive crops such as silk worm, cotton and tobacco.

Although Chinese agriculture is not completely free of state intervention, it has certainly made large strides over the last 16 years towards a market economy. The government is conscious of the fact that unless the communication and distributive structures are better developed, the farming community will be unable to bear the onslaught of open global competition. The Government intervention is clearly shown by their role in the last three years. In 1992, it reduced subsidies to state grain companies holding stock in corn and that resulted in the dumping of maize into the world market. However, in 1994, it raised the procurement prices of grains to boost farm income and to encourage greater production to meet the animal feed sector. Despite the measures, and due to the heavy demand for animal feed, China has to import coarse grains along with the wheat, whereas until a year ago, it was a major exporter of maize.

Over a medium term of five years, China will continue to import both wheat and coarse grains. It needs to keep the population well-fed to reduce social unrest. Total meat production, in which it became the largest producer since 1990, at present stands at 44 million tons against 33 million tons for the USA. The widening differential in production between China and USA in a space of four years shows the remarkable pace of growth.

In term of input such as fertilizers, it appears that the government will continue to ensure timely availability. Although application rates will not change dramatically except for the composition of crop-mix and the need to improve NPK balance, it is envisaged that more fertilizers will be needed to gradually reduce the proportion of organic manure used, estimated at around 12 million nutrient tons.

India

India has also a proud glorious past. Like China, it succumbed to the pressure from the industrializing West in the various stages between the sixteenth and nineteenth centuries. When it achieved independence in 1950, India adopted a very strong self-reliance and egalitarian policy. Although India was open to the modern technology that the industrialized countries had to offer, it was apparent that it had missed an early opportunity. It appeared that the founding fathers were devoting more time to leading the movement of the developing countries. It was only in the last three years, when economic development reached an impasse, that reforms began in earnest. Monetary reserves grew from less than US$ 2 bn to a present healthy US$ 20 bn and exports are now growing at over 20% per year.

The social development of post-Independent India was less traumatic compared with China. Imbued with and proud of being the world's largest democracy, India underwent gradual transformation. The attempt to restrain population growth by Indira Gandhi ended in great controversy and eventual failure. With the present population growth rate of 2.1% per annum and increasing life expectancy, India is expected to surpass China as the most populous country before year 2035.

In agricultural development, the increase in production was slow in the early years of independence. Efforts were concentrated on area expansion and improved cultural practices. After experiencing several drought seasons in the mid-1960's, real progress began in earnest with the introduction of hybrid seeds and proper fertilizer application. The success was astonishing. Instead of importing as much as 10% of the grains for consumption, India has been self-sufficient ever since, despite the population having doubled between 1960 and the present. And after seven successive good monsoons, it is now the world's third largest exporter of rice. As a result of the success, fertilizer is integrated into the national food policy and a separate Department had been created to handle all aspects of fertilizers.

The close linkage between the fertilizer and agriculture has been a subject of controversy both within and outside India. Internally, it appears that the fertilizer industry is singularly favoured and distinctly detached from the national industrial policy. Outside observers, especially the World Bank, often wonder why India should allocate so much of its meagre financial resources to a particular sector of the economy. Perhaps the consensus among the leaders in India is that food security outweighs all other priorities.

In India, the government has the monopoly of the gas supply. The price of the gas to the nitrogen manufacturers would determine both the farmgate price and the amount of subsidy for the fertilizers. At the onset, all fertilizers were subsidized and available at low prices to the farmers. The prices were increased on several occasions to reflect a closer linkage to prevailing international prices.

Perhaps the most dramatic change in recent years was the decontrolling of phosphatic and potassic fertilizers on 25 August 1992. The immediate impact was that it dramatically reduced the production of the less competitive phosphate plants and allowed the import of phosphate. Consumption of phosphates and potash was greatly reduced as the farmers switched to nitrogenous fertilizers which were still subsidized. To add to the difficulties of the Indian fertilizer manufacturers, the unification of the exchange rate of the rupee and its introduction to full convertibility denied the Indian manufacturers the advantage of the availability to them of the concessional rate that they had enjoyed previously.

Since that major change, the Indian government had made available an ad hoc concession allocation in June 1993 to the local manufacturers. For the 1994-95 Union Budget, two more major changes took place. AS, CAN, AC were decontrolled along with the Retention Price Scheme (RPS) and the subsidy scheme for these products. The present (6th pricing period) ends on 31 March 1996 and it is not clear what the future course of action will be.

DISCUSSION

Both China and India are linked by several common denominators - large population, scarce natural resources but the will to modernize. Beyond this, the similarities end. Table 3 provides a comparative difference between China and India with the data for US included as reference as a highly successful agricultural producer. China apparently opts for a fast track to modernization in the key industries. Overall, the rate of economic growth in the last ten years, except for 1989, has been over 10% per annum. This has resulted in high inflation, to as much as over 20% in 1993. Although the latter has been slowly curbed, industrialization has caused an even larger disparity between the urban and rural communities. The rural unrests of 1993 and 1994 had prompted the policy-makers to re-orientate their modernization programme. The farming community is becoming a focus of attention again. In the effort to accelerate changes in the farming sector, the fertilizer subsidy was withdrawn but the state purchase prices of grains were increased. In the longer term, China hopes to consolidate the farms into large co-operatives and tries to emulate the successful operations in the U.S. The rate of change will depend on how rapid the Chinese are able to develop the industrial and service sectors of their economy.

In term of food security, China is likely to adopt a more relaxed attitude toward grain imports. It realizes that growth in agricultural production will be slow and that the major infrastructures to control flood and alleviate drought will take time to build.

India will adopt a slower but more careful path to modernization. Parliamentary democracy revolves around consensus-building and this is probably one of the reasons. It is unlikely to reinstate drastic birth-control measures to slow population growth. India has a much larger area of arable land than China. However, a large proportion of this arable land is rain-fed. If rain-fed cropland can be rendered as productive as those of the plains of Punjab, then the food security problem will not surface for some time to come. At present, the Indians are largely vegetarian. With the growing affluence that accompanies its improving economic well-being, there is every chance that there will be a change towards higher meat content in their diet.

On the future of the fertilizer subsidy, it would appear that the change will be resisted for some time. The World Bank has always favoured increasing the support price of the produce. However, since the majority are subsistence farmers, this policy would favour only a relatively small number of large farms.

OTHER DEVELOPING COUNTRIES

In the other developing countries of Asia, the agricultural policy differs quite broadly. Most of them have shed the fertilizer subsidy scheme. Nearly all of them are self-sufficient in the key grain crops. All these countries are attempting to diversify from agriculture. For those that are successful, they tend to have a liberal policy of importing agricultural goods.

In Africa, due to the great diversity of countries and limited available knowledge, it is extremely difficult to produce a very coherent report on agricultural policy. Moreover, due to the many unrests, less attention has been focussed to modernize their agriculture.

At least until recently, the governments of almost all the developing countries of Africa were heavily involved in agriculture. This meant a high level of regulation, licensing, price control and import monopolies. Special public sector structures were responsible for the distribution of inputs and marketing of outputs, which were mostly aid-financed. These structures were generally inefficient. Fertilizer subsidies were widespread in sub-Saharan Africa, both implicit, due to overvalued exchange rates which made imports cheaper, and explicit through direct payments. Reasons for the maintenance of subsidies included compensation for low crop prices and for limited credit availability.

The commercial farming sector in Zimbabwe and South Africa has played and continues to play an important role. In South Africa the government's policy is to encourage small scale farming and some land distribution for this purpose.

Many African countries are significant producers of agricultural commodities and have benefited from the recent increases. The devaluation of the CFA franc has benefited agricultural commodity exports from the francophone countries of Africa.

During the 1980s, the World Bank committed itself to financial structural adjustment programs (SAPs) in 24 countries in Africa, and another 9 countries were affected by similar operations. Almost all these operations included conditions relating to agricultural subsidies. Their removal was justified on the grounds that they distorted the allocation of resources, precluded privatization of the distribution sector and that the burden on the national budget was too great.

Unfortunately, countries which have been the most successful in eliminating subsidies have often the worst performance in terms of fertilizer demand. In many SAP countries extension services deteriorated in the 1980s because of increased budgetary constraints. Farmers had difficulty in obtaining the required quantities of mineral fertilizers for a correct fertilization of their crops and even more difficulty in paying for them.

Fertilizer prices for the African farmer are high. The quantity of grain required to purchase one kg of nitrogen varies from 6 to 11 kg, compared to about 2 or 3 in Asia. The cost of imported fertilizer is high because of the small volumes and the cost of distribution is substantial, due to high transportation costs, small volumes, lack of storage facilities and inefficiency. And in general food crop prices are kept low.

Some countries, such as Ghana, Tanzania, Uganda and Zambia taking steps to liberalize their agricultural economies and to give the private sector a greater role, but in general the situation in most Sub-Saharan countries is not encouraging.

Latin America and the Caribbean are also undergoing major agricultural policy in the last few years.

Since 1990, Brazil has made its agricultural sector more market oriented. It has liberalized the import of wheat while guaranteeing the minimum price of rice, corn and dry bean. Tariffs on key imports have been reduced.

In Chile, the government has divided the agricultural sector into the free market sector where there is no government intervention and the protected sector. The free sector includes the export crops, fruits and vegetables. The protected sector includes the staple food grains, sugar, oilseeds and cotton. The prices of the protected sector - whether domestically produced or imported, must fall within a narrow band as regulated by the government.

Mexico has undergone many changes in recent years. Input subsidies such as fertilizers, water, electricity have been either reduced or abolished altogether. Since 1992, it has implemented or are implementing a series of land reforms. The peasant uprisings over the last two years indicated the seriousness of the agrarian problem. The recent entry of Mexico into NAFTA has obliged the government to lower or remove trade barriers including those involving agricultural goods.

Argentina is also de-regulating its agriculture. The changes which have taken place have no doubt stimulated agricultural intensification. For the first time in many years, fertilizer consumption has increased dramatically.

Venezuela is also liberalizing its agricultural programme by withdrawing subsidies (including fertilizers) and privatizing the state companies. Tariffs are reduced for imports.

Among the smaller countries in Central America and the Caribbean, there are less reforms taking place in their agricultural policy. Most of these countries still regard agriculture as an important component of their economy and wish to protect their exports.

CONCLUDING REMARKS

The agricultural policies of developing countries are undergoing major restructuring in recent years. Most of these changes are made in response to improved market accessibility which became possible with the ending of the Cold War. Even before the conclusion of the GATT's Uruguay Round of negotiations, many countries have already started dismantling tariff barriers and internal subsidies. When the Uruguay Agreement is implemented, all subscribing parties will have to adhere to the conditions laid down.

Although India and China have many similarities in demography and economic limitations, they adopt very radical approaches to their agricultural policy. The Chinese adopts a fast track to modernization despite its susceptibility to instability and social disruption. It requires constant monitoring and tight implementation. Relaxation of such regimes had led to rural unrest in 1993 and 1994. By providing incentives such as high guaranteed prices to the agricultural produce, it encouraged the amalgamation of small farms to enhance economic efficiency. Together with the rapid industrialization, it has resulted in major social disruption in which there is an estimated 150 million rural floating population.

India's more cautious and consensus approach to modernization is reflected in their agricultural policy. Their subsidies are predominantly at the input level. Social disruption is minimized by their support to the small subsistent farmers. India still places top priority to food security for she is conscious that any major shortfall in production will not be easily overcome by the production in granaries elsewhere.

Many developing countries are closely involved in non-cereal agricultural commodities - oilseeds, fibres, sugars, beverages, fruits, etc. After initial successes in the production of these commodities, they subsequently suffered dismal failures. Most developing countries do not have the resources or the stamina to protect their producers. Many of the control boards set up to monitor prices, product movement and stockpiling have to be disbanded or their roles minimized. The *laissez-faire* attitude of the developing countries towards non-cereal commodities will give rise to even larger fluctuations to price movement in future. Only recently, the price of coffee increased by between three to four folds within a space of less than one year.

In a closer scrutiny of agricultural policies among the developing countries, the importance of food security to national interest will undergo an economic litmus test. This may be seen with greater transparency if the allocation used to finance food production for security could be used for other urgent social agendas. Some fast emerging countries sacrifice food security to balance trade deficits in order to secure a smooth flow of trade.

Finally, the implementation of the Uruguay Round Agreement will provide an opportunity to developing countries to stimulate their agricultural development. In the absence of export subsidy and the disappearance of food surplus in the developed countries, many of the developing countries can no long rely on cheap imports or free food. There is no better way to get agriculture going than the present time.

Acknowledgments

The author wishes to thank FAO and the World Bank for the use of their published data, K.F. Isherwood for his helpful advice and L.M. Maene, Secretary General for his encouragement and support.

Table 1: Contribution of Agriculture to Countries' GDP's

Industrialized	%	Developing	%
Germany	1	Egypt	16
Belgium	2	Zimbabwe	18
Japan	2	Indonesia	19
UK	2	Senegal	19
USA	2	China	21
Australia	3	Pakistan	25
France	3	Vietnam	29
Italy	3	India	31
Netherlands	4	Bangladesh	33
Spain	4	Uganda	56

Source: World Bank

Table 2: Percent of Population in Agriculture

Industrialized	%	Developing	%
Germany	4	Egypt	39
Belgium	2	Zimbabwe	66
Japan	5	Indonesia	45
UK	2	Senegal	78
USA	2	China	64
Australia	4	Pakistan	48
France	4	Vietnam	58
Italy	6	India	65
Netherlands	3	Bangladesh	66
Spain	9	Uganda	79

Source: FAO

Table 3: Key Data (1993)

	China	India	USA
Total Area (m.ha)	960	329	980
Population (m.)	1180	895	260
Pop. growth Rate (%)	1.4	2.1	0.9
GDP ($ bn)	581	263	6387
Exports ($ bn) 1991	84	26	569
1993	128	29	703

Source: FAO/World Bank

Table 4: Agricultural Data (1994)

	China	India	USA
Cereals (m. ha)	88	101	64
Production (m. t.)	397	212	357
Yield (kg/ha)	4500	2107	5572
Rice - Area	30	42	1
- Production	178	118	9
Wheat - Area	30	24	25
- Production	101	59	63
Maize - Area	20	6	30
- Production	103	11	257
OTHER CROP AREAS (m. ha)			
Root crops	9.5	1.4	0.6
Oilseeds	20.5	28.0	26.8
Cotton	5.0	7.5	5.2
Sugars	1.8	3.6	1.0
Pulses	4.5	23.6	0.8

Source: FAO

AAPFCO Update

George Latimer
AAPFCO

INTRODUCTION

I very much appreciate your invitation to speak on behalf of the Association of American Plant Food Control Officials at the Round Table's 45th meeting. I do so as that Association's President in its 50th year of existence. Since the two organizations have a long association, I expect that your organization has been kind enough to extend the same invitation to many, if not all, of my predecessors, but for those who may not be familiar with the Association, let me briefly introduce it. AAPFCO is the forum through which officials of any state, territory, dominion or province on the North American continent, charged with the responsibility of enforcing the laws regulating production, storage, labeling, distribution, sale or use of fertilizers, may come together to:

1. promote uniform and effective definitions, rulings, and enforcement practices;
2. encourage and sponsor the adoption of the most effective and adequate analytical methods for fertilizer by all member agencies;
3. develop high standards of fertilizer inspection techniques and procedures;
4. promote adequate labeling and safe use of fertilizer;
5. provide facilities and opportunities for the free exchange of information, discussion, and cooperative study of problems confronting members of the Association; and
6. cooperate with members of industry to promote the usefulness and effectiveness of fertilizer products and the protection of soil and water resources.

There are two aspects of AAPFCO which I wish to bring to your attention. The first is the Association's membership is not limited to the United States of America, but embraces Canada, Mexico and other countries of the North American continent; thus, as you will see, as trade among countries grows, the Association must deal with a wide range of commercial and regulatory interests. The second is that AAPFCO cooperates with members of industry to develop rules which are as uniform as possible; it does not legislate rules or enforce them. Thus, AAPFCO both needs and values the contributions made by the Industry Liaison members who work with its committees, since it is, after all, the committees that perform the work of the Association.

With that short introduction, let me (1) summarize the actions of the Association during the past year culminating at the annual meeting in San Juan; (2) discuss what subjects will be occupying the Association's attention in the coming year; and (3) preview the issues which I believe both the Association and the members of the Fertilizer Industry must confront in the next 5-10 years.

COMMITTEE ACTIONS

As noted above, the real work of the Association is done through committees and task forces prior to the annual meeting. Time does not permit me to discuss the work of each, but rather let me summarize the work of those committees whose actions had the most direct impact on the Industry last year.

The Plant Directory Committee

TVA notified the Association some time ago that it would no longer publish the Fertilizer Plant Directory. After considering a number of options, among them contracting with an independent publisher, the Plant Directory Committee recommended, and the Board of Directors approved, discontinuing the Directory's publication. With the demise of the Directory, the need for the Committee has ceased. It disbanded with the thanks of the Board for the service of the members.

The Slow (Controlled) Release and Stabilized Fertilizer Task Force

This joint AAPFCO/TFI group, chaired by Dr. Wilbur Frye, Director of the Kentucky Division of Regulatory Services, recommended a draft policy statement on Slow Release and Stabilized Fertilizers which was accepted by the Board. The task force is now directing its work to develop the means to implement this policy. There was a meeting in San Juan; there was a meeting here last Sunday; there will be another meeting at the upcoming mid-year meeting in Las Vegas.

Cooperative Project with Agriculture Canada

Agriculture Canada has been active in two areas also of interest to U.S. Agriculture: (1) heavy metals in phosphates and (2) micronutrient fertilizers and composts containing human and animal pathogens and heavy metals. The Board accepted a recommendation of the Environmental Affairs Committee to form a heavy metals subcommittee and to exchange the information it collects with Ag Canada.

Uniform Bills

Revisions to the adulteration sections in the model document remain tentative until concerns about the impact of those revisions can be determined. More time was requested for reviewing the proposal for regulating horticultural growing media.

The Long Range Planning Committee

Under President Crenshaw's direction, the Long Range planning Committee met both at the San Antonio mid-year meeting in February and again at the annual meeting in San Juan. The purpose of the Committee is to plan the direction of AAPFCO programs. The outcome of these two meetings was (1) the organization of the committee and (2) the development of the following mission statement: the Committee's mission is to develop plans to ensure that AAPFCO is an effective and focused voice for the advancement of uniform fertilizer legislation.

ACTIVITIES FOR THE COMING YEAR

AAPFCO's efforts in the next year will be directed towards increasing AAPFCO's effectiveness. Let me discuss both our efforts within the organization as well as those which reach beyond those confines.

Internally

The Board has expressed its interest in developing a formal budgetary process. As part of that process, an overall expenditure sheet for the past five years has been developed and put into the Board's hands. In addition, the Education Committee under the direction of Ms. Janet Bessey-Paulson has been asked to develop an Operations and Procedures Manual to provide continuity and precedent for the Board. The Long Range Planning Committee will meet after the mid-year meeting in Las Vegas to begin the task of translating the mission statement into the reality that AAPFCO should become in the next ten years.

To help the Long Range Planning Committee in this effort, I am sending a survey to the Industry Liaisons to the AAPFCO committees. I know this is an additional burden to your already busy schedules, but your comments will be seriously considered and AAPFCO cannot reasonably proceed without having them.

Externally

AAPFCO is attempting to establish contacts with sister organizations with like interests, e.g., the Fertilizer Section of the American Chemical Society and the Feed and Fertilizer Committee of AOAC International; to solidify relations with groups such as ANSI and NASDA; and in Mexico to establish a consultative international position. To further AAPFCO contacts with Mexico, the brochures in Spanish describing AAPFCO are available through the Association's Secretary, Dr. David Terry.

To introduce ourselves to the outside world, AAPFCO will be introducing a Home Page on the World Wide Net.

ISSUES FOR THE FUTURE

Let me speak now to what I believe should be our joint agenda for the next several years.

Ammonium Nitrate

By resolution of the Board, AAPFCO has joined with TFI in agreeing to provide to all fertilizer registrants/licensees, educational materials and training on the safe use of ammonium nitrate as fertilizer.

The misuse of fertilizer by terrorists, frightening as it is, cannot be allowed to stampede legislators into passing unwise and unwarranted restrictions on its use. However, the Industry must take a very pro-active stance in providing absolutely factual information to the public - by absolutely factual, I mean information free of emotional advocacy that has characterized and does characterize many debates in America these days. This is essential, first because it is the right thing to do, but, second, because AAPFCO, composed as it is of regulatory officials, cannot afford to be identified as other than impartial in any debate. The AAPFCO Educational Committee is structured in a way which will allow the organization to provide the maximum help. Please provide the Chair of that Committee with your needs through the industry liaison.

Compost, Sludges and Wastes as Fertilizers

Many states are seeking to maximize their markets for composts, sludges and wastes by touting them as fertilizers, but their distributors are not interested in their being regulated as fertilizers. In the last legislative session in Texas, there was a bill which would have allowed these products to call themselves fertilizers, make fertilizer claims and enjoy the protection of the Fertilizer Law, but pay only 25% of the tonnage fee cost borne by manufacturers of commercial fertilizers. It was defeated; however, the need to deal with this problem constructively both in Texas and nationwide requires consensus so that industry and AAPFCO can structure an appropriate response to the legitimate need to dispose of waste. Without a generally agreed upon position, AAPFCO members will not be in a position to advise legislators on the best approach to regulation, and uniformity in approach, in labeling and enforcement may be lost. There is a second serious issue. Many products which are presently being thought of for incorporation in fertilizers may or may not release their available nutrients to the environment. For the most part, the marketplace should weed out those that do not. However, how do we as regulators exercise reasonable control over these products before they get into the marketplace so that a buyer doesn't lose his crop because necessary nutrients are not provided. Regulatory agencies cannot perform availability studies before a product comes into the marketplace; however, it is possible that they could require the industry promoting such products as fertilizers to provide data in support of the effectiveness and efficacy of its products. AAPFCO needs your advice.

The Regulatory Climate

No one can ignore the legislative interest in ensuring efficiency and effecting cost reduction in administering regulatory programs; it is necessary and AAPFCO supports it. But there are several dangers to industry in this process. First and foremost, some states promote efficiency by abolishing fertilizer programs, but keep the fees coming in. In that case, industry gets nothing for something. More commonly, regulatory officials are asked to do more with less. There is a limit, however, because when the fat is gone, industry gets less of everything for the same something. Perhaps it is time AAPFCO and the industry examined the Canadian program of self-monitoring; such a program might be adapted to the U.S. situation at reduced regulatory costs. Second, is that without significant industry effort, uniformity in labeling and commonality in methods which has been achieved over the years may be in the process of being lost. Both Teresa Crenshaw and I are receiving calls asking AAPFCO's help in dealing with labeling provisions which conflict with labeling rules of other states and methods which differ from those commonly accepted through AOAC. AAPFCO can help negotiate differences in labeling, but, when different state laws prescribe different approaches, AAPFCO is helpless. If uniformity is important to the fertilizer industry, then the industry must take the initiative with legislators in the various states to convince them that their state's fertilizer administrator should be given the latitude to bring problems to the appropriate AAPFCO committees rather than the legislature's imposing arbitrary requirements upon him/her. I believe, in return, industry should be able to tell a legislator or an administrator of a program that AAPFCO will deal with concerns in a prompt manner; if AAPFCO's procedures are not "prompt" enough, then AAPFCO needs to devise procedures which are "prompt." Please notice I say "prompt," not immediate. No organization such as AAPFCO which is consensus-based can issue an immediate decision.

The federal government continues to expand its regulation of fertilizers, not directly, but indirectly through EPA and USDA. That regulation is exercised through laws, regulations and rules which serve (1) to control non-point source pollution, (2) to define appropriate means for the containment of fertilizer and its raw materials and (3) to require the use of the certified crop analysts to ensure that fertilizers are used wisely and at a minimum. Such indirect controls are evident in the Whole Farm Plan, in the Coastal Zone Management Act and in the National Organic Standards Board which were created for different purposes, but indirectly impose requirements on fertilizers. Without your support, state regulatory programs may, as a matter of fact if not in law, be supplanted through this regulatory approach.

CONCLUDING REMARKS

Some 125 years ago, Massachusetts passed the first state fertilizer law entitled an "Act to Prevent the Manufacture and Sale of Adulterated Commercial Fertilizer." That goal, old as it is, should still be the aim of the states, AAPFCO and industry since that goal can only be achieved through the combined efforts of the states, AAPFCO and industry. Consultative participatory forums such as the Round Table perform a valuable service not often recognized as such. You should be proud of the contribution these meetings make to everyone in the fertilizer community.

Impact of Development of New Crop Cultivars on Fertilizer Usage

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Introduction

There has been considerable interest the last quarter of a century in developing new crop cultivars that require reduced or little application of fertilizer. Several different factors have sparked interest in developing these new cultivars. The primary motivation in the 1970's and early 1980's was the energy crisis. The potential lack of nitrogen at affordable prices resulted in breeding for increased nitrogen fixation of legumes and work on trying to develop cereals that would produce their own nitrogen. More recently selection for cultivars that produce reasonable yields with reduced inputs has been emphasized. Several factors have motivated this work including the desire to improve yields in developing countries where farmers cannot afford chemical inputs including nitrogen. In more developed countries environmental concerns about nitrogen and other nutrients contaminating ground and surface waters and the desire of some groups to develop an alternative system of agriculture that requires few off-farm inputs have stimulated breeding for cultivars that require the application of fewer nutrients. To address these concerns and respond to these demands, breeding and crop improvement research has been concentrated in the following areas:

1) breeding for increased nitrogen fixation of legumes,
2) transferring the ability to fix nitrogen to non-legumes, and
3) developing cultivars that are more effficient in nutrient uptake and utilization.

This work has focused on nitrogen although there has also been some research on phosphorus and other minor nutrients. This paper will briefly review the progress made by breeders and plant molecular biologists in these three areas and will provide some insight on the impact of this research on use of fertilizer in the future.

Fertilizer Use and Plant Breeding

Almost since the development of corn hybrids in the 1930's until the present, plant breeders have focused on selecting nitrogen-responsive cultivars that produce higher yields. In the USA the biggest increase in demand of nutrients has been for nitrogen. Nitrogen fertilizer use on a per unit area has continued to increase or remain steady for most major crops. Since 1964, the increased use for nitrogen fertilizer has largely been in corn and wheat. These two crops accounted for 35 percent of all nitrogen used in 1964 but 54 percent in 1985.

On a global basis, cereal production dominates cultivated land use (about 50% of total area). Legumes are grown on 11 percent of the world's arable land. Improved cultivars of cereals have all been bred to be responsive to nitrogen. The green revolution occurred because plant breeders developed rice and wheat cultivars that would produce high yields when heavily fertilized with nitrogen. A nearly doubling in cereal production between the early 1960's and 1990 has been attributed in part to a seven-fold increase in fertilizer nitrogen use. Globally the use of fertilizer nitrogen increased from 8 to 17 kg per hectare during the 15 year period from 1973-1988. Many feel that although the demand for food will increase because of continuing population growth, the era of changing the environment (i.e. adding nutrients such as nitrogen) to fit the needs of current cultivars has passed. A key to developing low-input, technologically advanced, sustainable production systems will be the breeding of plants with improved nutrient uptake and utilization efficiency.

Progress in Breeding for Plants to Reduce Nutrients from Fertilizer

Increased nitrogen fixation of legumes.

Although it is acknowledged that biological nitrogen fixation can play an important role in sustaining productivity, a recent summary of the role of nitrogen fixation concludes that plants which can fix more nitrogen under sole cropping or intercropping must be developed. Because of the association between yield and nitrogen, selection for grain yield in grain legumes indirectly selects for nitrogen fixation. By the early 1980's, several breeding programs involving a range of species and research organizations had been initiated to directly select for increased biological nitrogen fixation.

From that considerable effort, only a few cultivars, most notably of common bean, have been released specifically for improved nitrogen fixation. One has to conclude that there has been little success. Although progress has been made there has been almost no impact of nitrogen from legumes replacing fertilizer nitrogen by breeding for increased nitrogen fixation of legumes. Furthermore, even if success is achieved in the future, it will probably require at least another decade, if then, before the impact of breeding legumes for increased nitrogen fixation could reduce the need for nitrogen fertilizer. The greatest immediate benefits from biological nitrogen fixation are likely to be achieved with relatively simple technologies for which the technology understanding is already sufficient. Gains from plant breeding are likely to be modest and longer term than the gains in the amount of nitrogen fixed due to the introduction of a legume into the cropping system.

Extending Biological Nitrogen Fixation to Non Legumes

In the early 1970's several scientists working in the field of symbiotic nitrogen fixation reported that the transfer of nitrogen-fixing (nif) genes into plants was within reach. Recently, deBruign et. al. (1995) reviewed the progress that has taken place in transferring nitrogen-fixing ability to nonleguminous plants such as rice. Numerous physiological and biochemical obstacles need to be overcome before the goal of nitrogen-fixing cereal crops will be realized. Kennedy and Tchan (1992) believe that effective nodulation of nonleguminous plants will eventually be achieved. They conclude that the next ten years will tell whether their confidence is justified. The creation of nitrogen-fixing cereal crops, whether by induction of nodulation or by genetic engineering of cereal crops is a very distant goal.

Even if cereals could fix their own nitrogen, it could lead to other problems for agriculture.

Breeding cultivars with greater emciency in nutrient uptake and utilization

Genetic control of plant nutrition is generally complex for macronutrients and relatively simple for micronutrient emciency factors. The inheritance of nitrogen utilization efficiency is governed by four major variables all under separate genetic control. Atlin and Frey (1989) concluded that corn hybrids can be selected for specific adaptation to reduced nitrogen fertility and that the most effective way to develop such hybrids is to select them under low nitrogen conditions. They believe that many cases exist where breeding programs for cultivars specifically adapted to low-input environments are needed to maximize production in countries where purchased inputs are inaccessible to most growers and to serve the growing community of North American farmers who are choosing to reduce their use of off-farm inputs. Work at CIMMYT which has selected for a constraint at locations where the constraint is endemic supports these conclusions. They report that gains are being made in breeding for tolerance to low nitrogen, a special trait that should enhance corn's productivity in areas where farmers apply little fertilizer. Work in Thailand confirms that considerable genotype variation for nutrient content of corn grain exists. Cultivation of cultivars with low nutrient content in the grain may reduce the need for fertilizer. Progress in developing cultivars that take up or utilize nitrogen more efficiently is possible although this work will probably have little impact for at least another decade.

Conclusions

It is estimated that 80 to 90 million tons of nitrogen fertilizer will be applied to agricultural land by the year 2000. It is highly unlikely that breeding of new cultivars will reduce this requirement in the near future although biological nitrogen fixation via the introduction of more legumes in the cropping system could have an effect. It appears that the earliest products of plant breeding that will have a significant impact on fertilizer use will be cultivars that yield well under low nutrient conditions.

References

Peoples, M.B., D. F. Herridge and J.K. Ladha, (1995). Biological nitrogen fixation: an evident source of nitrogen for sustainable agricultural production? *Plant and Soil* 174:3 28.

Committee on the role of alternative farming methods in modern production agriculture, Board on Agriculture, National Research Council. *Alternative Agriculture.* National Academy Press, Washington D.C., 448 pp.

Bliss, F.A., P.A.A. Pereira, R.S. Aranjo, R.A. Henson, K.A. Kniecik, J.R. McFerson, M.G. Teixeira and C.C. da Silva. (1989). Registration of five high nitrogen fling common bean germplasm lines. *Crop Science* 29:240-241.

Wani, S.P., O.P. Rupela and K.K. Lee. (1995). Sustainable agriculture in the semi-arid tropics through biological nitrogen fixation in grain legumes. Plant and Soil 174:29-49.

Herridge, D.F. and S.K. A. Danso. (1995). Enhancing crop legume N_2 fixation through selection and breeding. *Plant and Soil* 174:51-82.

Giller, KE. and G. Gadish. (1995). Future benefits from biological nitrogen fixation: An ecological approach to agriculture. *Plant and Soil* 174:255-277.

Bonnet, J. and J.K. Ladha. (1992). *Introduction: feasibility of nodulation and nitrogen fixation in rice.* In *Nodulation and Nitrogen Fixation in Rice Potentials and Prospects.* Eds. G.S. Khush and J. Bennet. pp. 1-14. IRRI, Los Banos.

Bruijn, F.J. de, Y. Jing and F.B. Dazzo. (1995). Potential and pitfalls of trying to extend symbiotic interactions of nitrogen-fixing organisms to presently non-nodulated plants, such as rice. *Plant and Soil* 174:225-240.

Kennedy, I.R. and Y. Tchan. (1992). Biological nitrogen fixation in non-leguminous field crops: Recent advances. *Plant and Soil.* 141:93-118.

Graham, R.D. (1984). Breeding for nutritional characteristics in cereals. *Adv. Plant Nutr.* 1:57-101.

Altin, G.N. and K.J. Frey. (1989). Breeding crop varieties for low-input agriculture. *American Journal of Alternative Agriculture.* 4:53-58.

Winkelmann, D.L. and G. M. Listman. (1993). Corn in the developing world and the international maize and wheat improvement center. *Food Reviews International.* 9:315349.

Feil, B., R. Thirapom and P. Stamp. (1993). Can maize cultivars with low mineral nutrient concentrations in the grains help to reduce the need for fertilizer in third world countries. pp. 295-299. In P. J. Randall et al. (eds.) *Genetic aspects of plant mineral nutrition.* Kluwer Academic Publisher. Netherlands.

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Session IV
Moderator:

Vernon Carlton

Fertilizer Dust & Dust Control Coating Agents

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ARR-MAZ Products

Dust is a universal phenomenon and is associated with the manufacture of just about any dry, solid material. Fertilizers are no exception. Dust is a natural by-product of the processes involved in the manufacture, storage and transportation of fertilizers. In spite of the best efforts to prevent dust, it will be generated throughout the life span of the fertilizer. There are a number of different factors which work together to determine the dust levels that will be found in a fertilizer product. Understanding these factors is an important step in the effort to minimize and control dust levels.

Fertilizer dust consists of fertilizer particles which are small and light enough to become airborne and which remain airborne long enough to cause a problem. Excessive dust is a headache for both producers and end users. The problems it creates include environmental compliance, worker safety, worker productivity, and increased equipment maintenance and repair. Because of this low dust levels are becoming increasingly linked to the concept of fertilizer quality.

In the field subjective, visual observations are often the only way to measure the "dustiness" of a fertilizer. However, more direct measurements can be made in the laboratory using a 'dust tower'. Figure. 1 is a sketch of this test unit. To test for dust, a sample of fertilizer is poured into the 'dust tower'. The granules tumble through a counter current air stream. The dust present in the sample is picked up by the air and collected on a filter.

By running a series of tests the dust levels in a fertilizer can be determined and the effects of dust control agents can be evaluated. The results from a typical dust test series can be seen in Graph 1. Dust levels will vary from fertilizer to fertilizer, as will a coating agent's ability to control dust. By using a well designed coating agent significant reductions in dust levels can be demonstrated in the lab, and these reductions translate to low dust levels in the field.

The factors which determine the amount of dust that will be found in a fertilizer sample can be broken down into two groups. Group number one includes the physical properties of the granules themselves, the type of and amount of mechanical handling involved, the length of time in storage and the storage conditions involved. Second are the properties of the dust control coating agent plus the coating agent application method and rates. The first group of factors revolve around the fertilizer itself, and they determine the ease with which dust will be generated and the opportunities that exist for dust formation. The next group relates to the effectiveness of the coating system and the efficiency of the coating agent.

Fertilizer granules are produced by the variety of methods and each fertilizer will have its own characteristics. Common production methods include agglomeration, compaction, melt granulation and prilling. Agglomerated granules tend to have rough surfaces and to be porous. Compacted granules typically have angular shapes and can be brittle. Melt granulation tends to produce round, hard granules. Prilling methods normally produce round, smooth granules which tend to be brittle. No matter how a fertilizer is produced, these characteristics or substrate properties will be the determining factors in dust formation and coating agent effectiveness. Those substrate properties which effect dust formation and control are listed in Table 1 and each deserves a closer review.

The size of the fertilizer has a direct relationship to dust levels and dust control. This is because an overall smaller size distribution will result in an increased number of granules per unit volume. An increased number of granules results in more contact points between surfaces and more rough edges to break off and form dust. The surface area of the fertilizer also increases dramatically as the granule size goes down. In the same way that a larger room needs more paint to cover its walls than a smaller room, a fertilizer with a larger surface area will require increased coating agent application rates. One way to look at this is to plot the fertilizer Size Guide Number (SGN), or "average" granule size against the calculated surface area. This can be seen in Graph 2.

The theoretical 'film thickness' of a coating agent can be calculated from the surface area and a known coating rate. The relationship between granule size (SGN) and film thickness at a coating rate of one gallon per ton can be seen in Graph 3. Note that the coating agent film thickness doubles as the size of the granules increases from an SGN of 200 to 350. Smaller granules are also weaker and more easily degraded. For these reasons the granule size distribution should be as large and narrow as possible. An example of the granule size distribution of two fertilizer samples can be found in Graph 4.

The shape and texture of the fertilizer particles are also important factors effecting dust formation and dust control. Rough or irregular shaped granules will have larger surface areas than round granules. Sharp edges and small projections tend to break off and form dust. It is also harder to get a coating agent to spread over an irregular surface. Roughly textured granules will have a similar effect on dust levels and coating agents. Surface areas on rough granules will be higher, and the ease with which the coating can spread will decrease. Although complete granule coverage may not be required to control dust, a minimum amount of the surface area must be treated for the coating agent to be effective.

Porosity is the amount of air spaces or voids within the granule. Some fertilizers are naturally more porous than others. Liquid coating agents will tend to "strike into" or be absorbed into a porous granule. This makes it difficult to get the coating agent evenly distributed across the granule surface. Absorption removes the coating agent from the surface where it is needed and is one of the main factors limiting the 'longevity' of a coating agent.

Granule hardness and abrasion resistance must also be included in this discussion. While they are related, hardness and abrasion resistance are not the same. Hardness is a measure of the force required to crush a granule. A granule can be very hard but still be very brittle or friable. A brittle granule will tend to fracture and form dust regardless of the granule hardness. As long as a granule has a minimum hardness and good abrasion resistance it will not be prone to "dusting".

Other granule qualities which help determine dust levels and coating effectiveness include the initial product temperature, temperature variations, moisture content, and continuing chemical reactions. The 'chemistry' of a fertilizer granule does not stop when it reaches the warehouse floor. Raw materials continue to interact and the fertilizer will react with the environment throughout its life span.

The equipment used in the production, transfer and storage of fertilizers create the conditions necessary for dust to form and become airborne. Pinch points and the other mechanical actions involved put stress on the granules. This stress results in the crushing, grinding and polishing of the granules and the formation of dust. Where ever possible the least abrasive devices should be used. Every time a fertilizer is moved or handled additional dust can be generated. Ideally the number of times a fertilizer is handled should be kept to a minimum.

Dust levels tend to increase over time. This is aggravated by prolonged storage and with less than ideal storage conditions. The effects of temperature, moisture and the 'reactivity' of fertilizer products are all amplified over time. It is best to keep storage times to a minimum and the storage area should be well sheltered from the weather.

Even after all possible steps have been taken to reduce the formation of dust, the dust levels in a fertilizer may still be unacceptable. This is where dust control coating agents come into play. They can be very effective in eliminating residual dust levels. Dust remains airborne for the same reasons a feather floats on the breeze. It is fertilizer particles light enough to be carried away by the air. Coating agents do their work by increasing the weight of the dust particles to the point where they cannot become airborne. Coating agents accomplish this by one of three ways. First, the coating can encapsulate a single dust particle and directly increase its weight slightly. A more dramatic way to increase weight is for the coating agent to agglomerate several dust particles into a larger, heavier group. The third way is for the dust particle to become attached to the surface of a larger granule. Ideally the adhesion of dust particles to larger granules is the way coating agent should operate. Enough coating agent must be applied to the granules to trap any fugitive dust in the fertilizer.

Dust control coating agents are typically liquid, at least at the time of application. They are normally applied by pumping and spraying them onto the surface of the fertilizer being treated. Several steps are involved to get a uniform coating over all the granule surfaces. First the spray is directed at a moving stream of fertilizer and comes in contact with the granules. As the granules pass through the spray only a portion of them will come in contact with the coating agent. It is just not practical to expect the coating agent spray to hit every granule. Some granule to granule contact is necessary to 'spread' the coating agent over the rest of the fertilizer granules. The amount of mechanical mixing available to spread the coating agent is a major factor in the application coating agents.

Proper mixing will allow for the most efficient use of the coating agent. Increased coating agent rates will be needed to make up for a lack of mechanical mixing. Coating agent application rates will vary from fertilizer to fertilizer and from producer to producer. The coating rates required to control dust will depend on factors such as the physical properties of the fertilizer, the dust levels present, the coating application system, the coating agent, and the length of time the dust control treatment is expected to last.

To be effective, a dust control coating agent should have the properties listed in Table 3. The coating agent should not evaporate or be absorbed into the granule. The coating must remain on the surface of the granule to be effective. The coating should have the ability to spread easily over the granules and cover as much of the surface area as possible. It should bind dust particles but not granules. The object is to reduce dust, not create caking. A non-drying coating will not change over time and this helps to maintain long term effectiveness. Once a coating has dried or hardened it has lost it's ability to pick up dust. The coating should not change the nutrient release profile of the fertilizer. It should be convenient to use. Coating agents must also be cost effective and environmentally friendly.

A typical coating agent application system will include a storage tank and pump. The tank may need to be heated depending on the properties of the coating agent. Product feed lines carry the coating agent to a flow controlling device, and there is usually a recirculation line back to the storage tank. The coating agent is delivered to a spray head which can consist of single or multiple spray nozzles. Single sprays can be effective and have the advantage of simplicity and reduced maintenance. Standard "V" spray patterns are normally sufficient and the nozzles can be either air assisted or straight hydraulic.

The mixing device used to finish the spreading of the coating agent completes the application system. This device should provide the most complete mixing with the least amount of abrasion. Coating drums work well and provide excellent mixing with minimal degradation. Specially designed ribbon blenders can also be very effective. Screw conveyors can be used, but tend to have higher levels of product degradation and some modifications are required to increase the amount of mixing involved. Coating chutes and other devices can also be used for coating agent application. The choice of the application system depends on a number of factors which include (but are not limited to) production rates, space available, and the amount of capital investment involved.

The location of a coating system will depend on the needs of the individual producer. The coating agent can be applied just about anywhere there is a moving stream of fertilizer particles. Some producers apply the coating agents in production right before the fertilizer is sent to storage. Others are treating the fertilizer as it is being loaded for shipment. Many producers coat in production to keep the dust levels down in their own plants, and then coat again at shipping to control dust for the customers downstream.

In conclusion, dust levels in fertilizer products are determined by the characteristic of the granules and the methods used to handle it. Dust control coating agents need to be properly designed and applied. By optimizing the fertilizers' properties and handling methods along with the an efficient coating system and a quality coating agent, the levels of dust in fertilizers can be efficiently controlled.

ARR-MAZ Dust Test Unit.

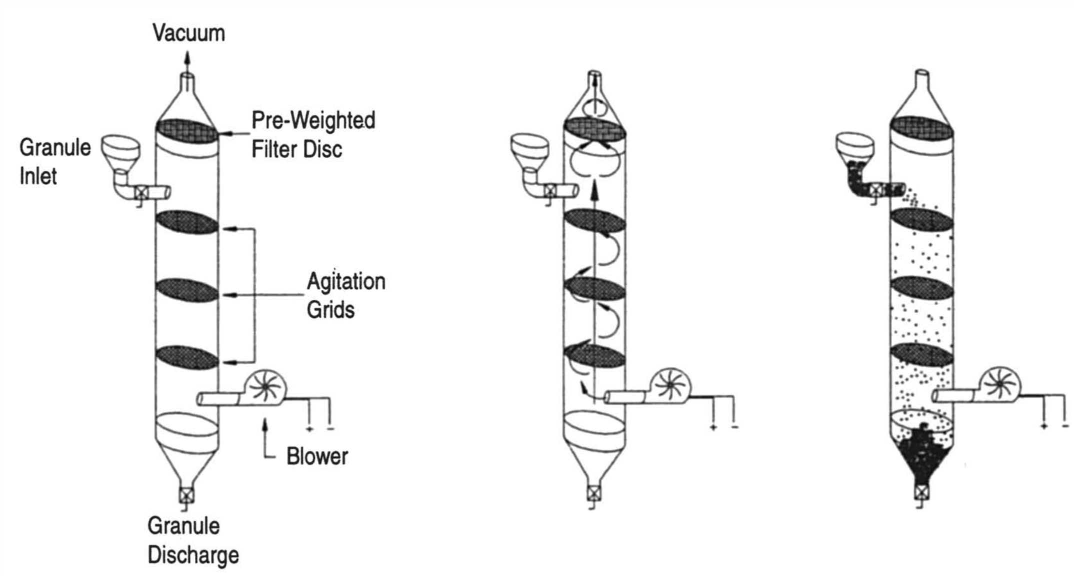
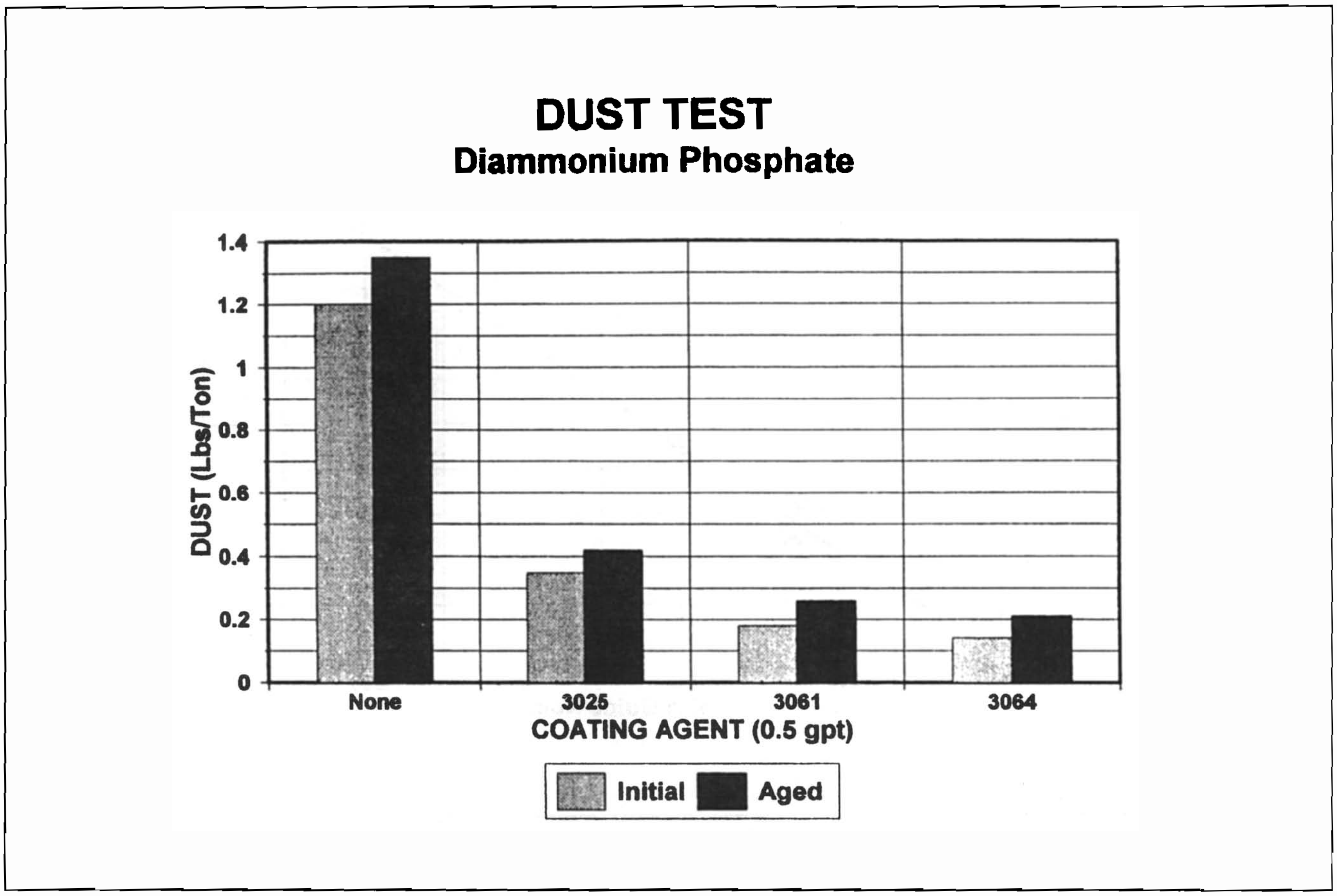
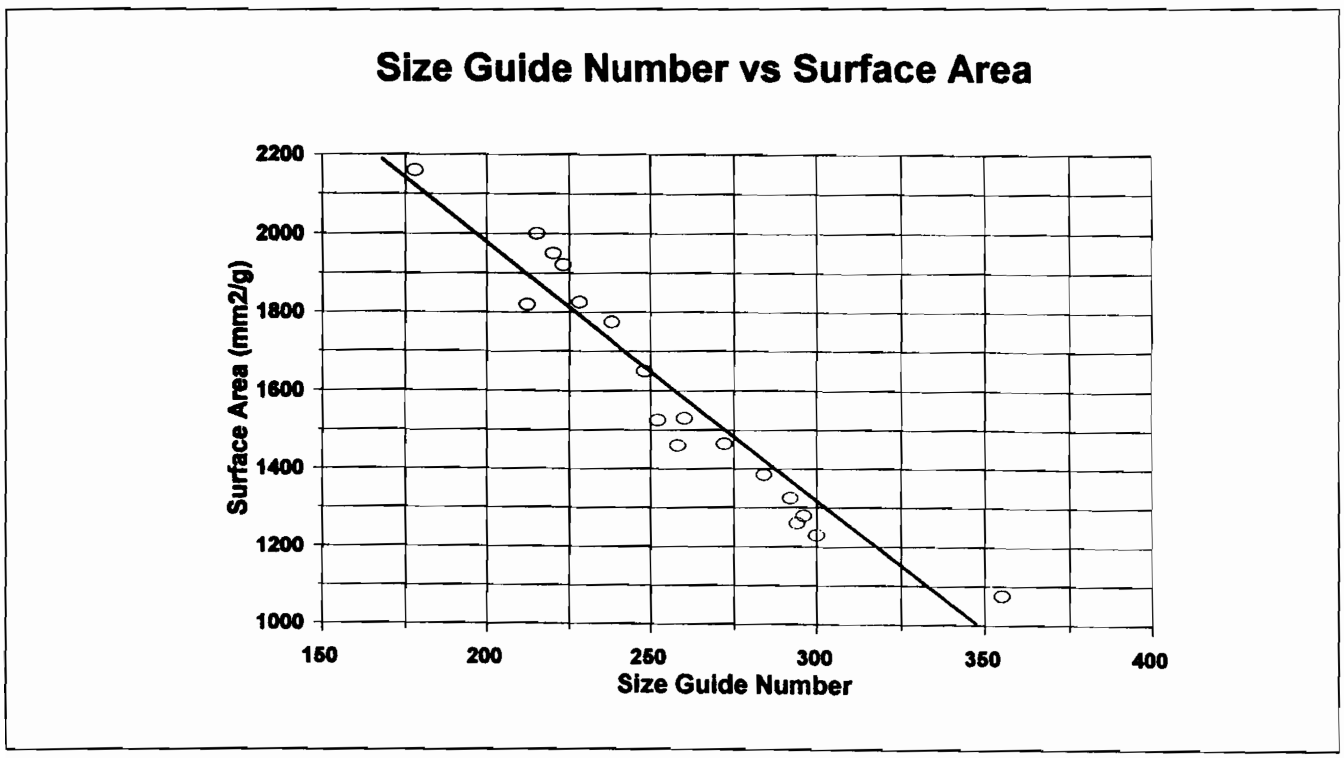


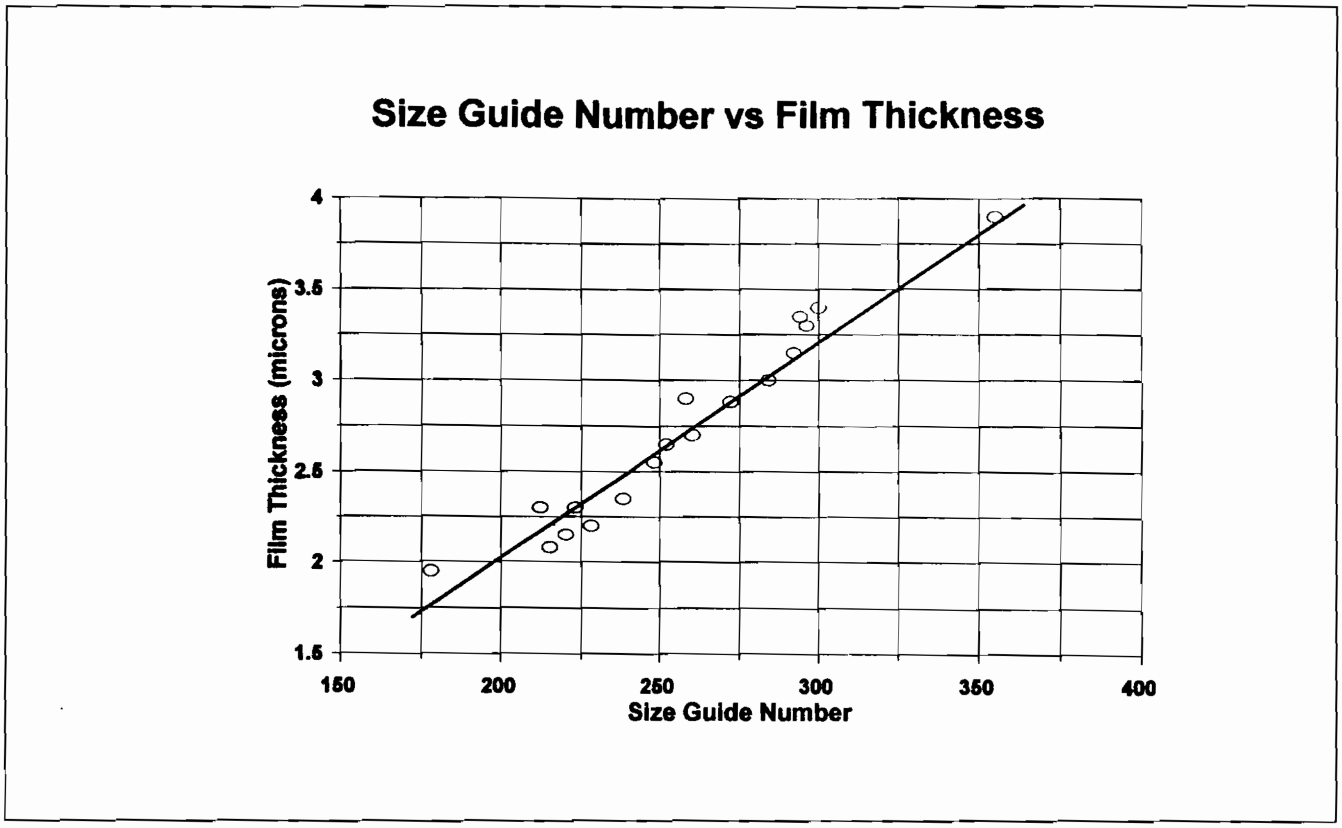
Figure 1.



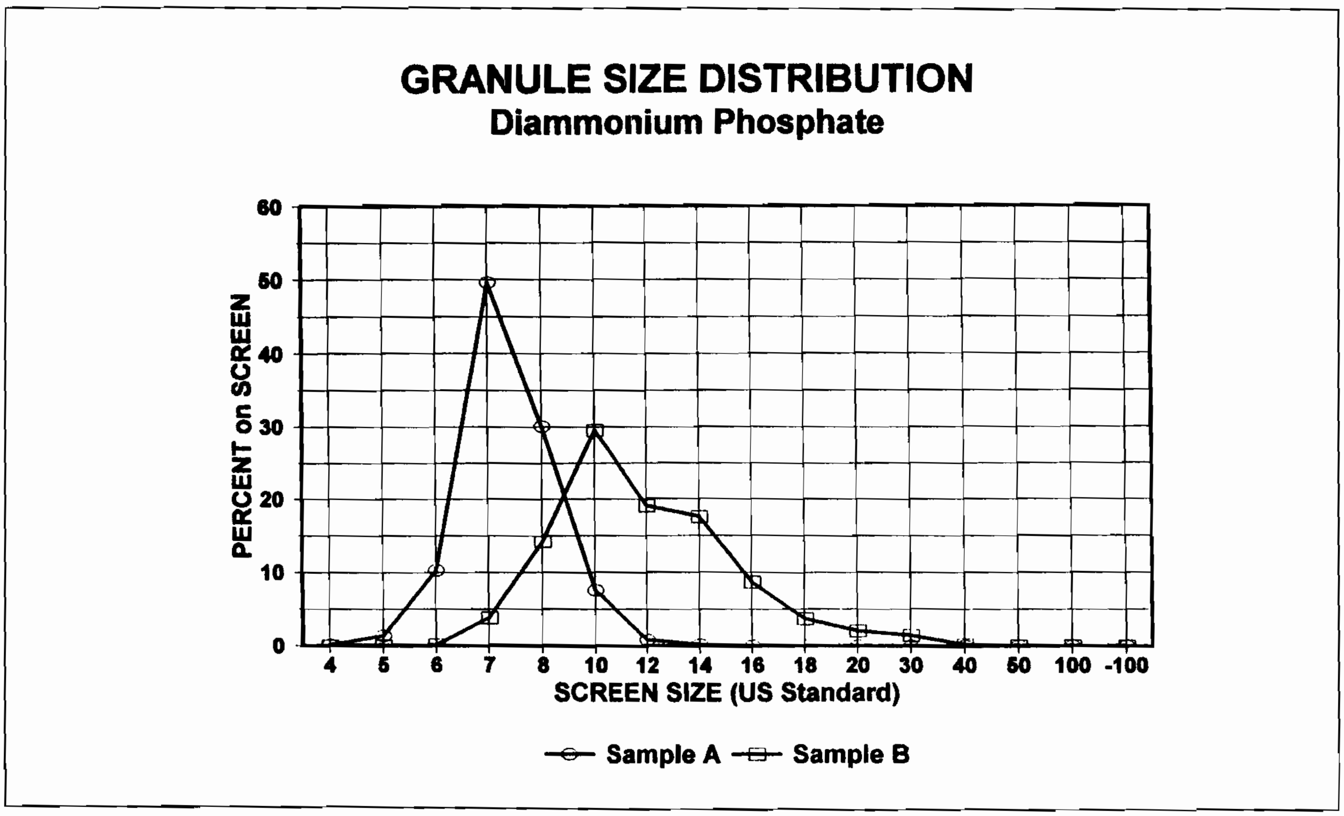
Graph 1.



Graph 2.



Graph 3.



Graph 4.

Equipment for Dust Control in Fertilizer Plants

Robert E. Robinson
Consultant

Introduction

Pollution can be defined as being any harmful or undesirable effect generated or released by any source. Harmful effects may be caused by release of gaseous, liquid, or solid substances, heat, or noise. Sources include industrial processes and natural events. The fertilizer industry is particularly concerned with air and water pollution arising from manufacturing, material handling and transport operations.

Dust in fertilizer plants is generated and dispersed from a wide variety of sources and in most plants is a pervasive problem. Dryers, coolers, mixers, conveyors, elevators, screens, and pulverizers all generate dust. Front end loaders often spill portions of their loads and generate air borne dust when picking up and dumping. Vehicle tires crush granules, making and stirring up dust from work aisles constantly. Bulk loaders and reclaimers dust. Material dropping onto storage piles dusts. Virtually every plant is different.

A variety of equipment is used to control pressures and flows and to collect air borne dust. The space requirements, capital costs, and operating costs for dust control and collection has become enormous.

Physiological Effects of Dust and Chemicals

Despite years of study and education, the physiological effects of pollutants on human beings and other living creatures are still not fully understood by much of the world's population.

A recent study done by Harvard and Brigham Young Schools of Public Health researchers co-authored by Douglas W. Dockery in Boston has correlated air pollution data for 151 U.S. cities from a 1980 EPA report with individual health risk factors for 552,138 individuals who had lived in those areas between 1982 and 1989 and who had participated in an American Cancer Society prevention study.

The focus of the study was to separate and reveal the effects of small particles having diameters less than 2.5 microns. EPA standards to not separate fine particles. Larger particles are more easily trapped and expelled by the upper body's air passages while fine particles penetrate deeply into the air sacs in the lungs where they remain and damage tissue.

Concentrations of small particles less than 2.5 microns in diameter ranged from 11.7 to 42.1 micrograms per cubic meter, and after factoring out other individual risk factors, a 15% increase in risk of death was determined for those living in cities having the dirtiest air compared to those living in the cleanest air.

Fertilizer manufacturing operations typically have exposures to ammonia, acid mists, and fine dusts. In addition to statutory EPA requirements to meet pollution codes, OSHA regulations and moral ethics prescribe the provision of good ventilation, safety showers and eye washing stations for plant workers. Workers should wear protective clothing, shoes, gloves, eye goggles, and have proper individual face mask breathing equipment for use in upset conditions. Proper safety procedures and training are essential.

Types of Equipment For Dust Control

Three principal types of dust control equipment are used in the fertilizer industry. Cyclone dust collectors are inertial mechanical separators used for collecting coarser dry dusts. Cloth filter dust collectors are used for all dry dusts. Wet scrubbers are used for all dusts, acid mists and gaseous pollutants. There has been increasing use of two-stage collection, with a primary first stage collector followed by a secondary collector in tandem, especially in systems with large air flows to achieve specified emission levels at the most economical cost and with the greatest dependability.

Dryers and coolers account for the largest stream volumes.In many installations it has been possible to take cooler cyclone exit gas mixtures into dryers as part of the secondary dryer air. This results in a reduction of total gas flow to the atmosphere and reduces the cost of air cleaning equipment required.

Dust collection units may be only part of air handling systems which also enable process units to operate. Other components of every air handling system include duct systems and exhaust fans.

Cyclone Dust Collectors

Cyclones are static structural devices configured to receive dust laden gas streams moving at specified velocities. They impart centripetal motion and acceleration to the gases in a downward helical spiral or vortical flow. The dust particles have greater weight, density and inertia than the gases and are thrown to the outer edge of the vortex. They are thus separated and settle along the cylindrical and conical collector walls and are collected at the bottom of a cone section in a dust receptacle hopper. The collected dust is discharged through an air lock discharge valve. The cleaned air is removed from the center of the collector at the top in a smaller higher velocity inner vortex through a central cylindrical tube called a vortex finder.

Cyclones can be quite efficient but in fertilizer applications single stage cyclone collection rarely exceeds 99% and cyclones alone usually do not meet current pollution code requirements. Cyclones are designed and sized for particular dust loadings, sizes and kinds of dust and their engineering involves fluid dynamics of the gas stream, particle mechanics of the dusts, and the size and design details of the cyclone. Cyclones can be designed for coarse, medium or fine dusts and for heavy, medium, or light dust loadings.

In dry cyclones, dusts are kept dry, which may be a process advantage for downstream handling. The bottom part of the cone section and the dust receptacle hopper should be made from heavy plate to withstand hammering to dislodge sticking solid material which may occur at times. Poke holes with removable caps in the receptacle and lower part of the cone should be provided to aid in rodding out material flow stoppages.

Cyclone Performance and Improvement

Some years ago a fertilizer dryer system with cyclone collectors was tested five times on a low nitrogen N-P-K grade, once as originally found and after each of four inexpensive system modifications. Particulate losses were reduced each time.

In determining the fractional efficiency of a cyclone the inlet and overflow particle loadings are determined for a set of particle size groupings. This can be obtained by sampling and analyzing both inlet and outlet streams. The efficiency for each size grouping can then be calculated. Indications are that overall efficiencies can reach approximately 99%, can exceed 50% at 4 microns, and possibly be somewhat effective down to 2.5 microns on fertilizer dusts.

Design features favorable to efficient air handling and good dust collection include straightness of duct systems with a minimum of turns, use of long gentle transitions, long radius elbows, large entry sections, and smooth, tight inside surfaces. Doors and joints must be tight and true, and kept tight to prevent inward air leakage. No turns or elbows should be placed just ahead of the cyclone or fan inlets to minimize turbulence. The dust receptacle collection hopper and valve at the bottom of the cyclone cone section should be kept as air tight as possible because inward air leakage can destroy the vortex action and cause reentrainment and loss of previously separated dust in the cyclone.

The true specific gravity for most fertilizer dusts ranges from about 1.8 to 2.2, and duct velocities for transport of the dust with minimum of settling or "salting" out is usually placed at about 3600 to 4000 ft/min., which keeps the pressure drop reasonably low. Higher duct velocities require more pressure drop and fan horsepower. The duct inside diameter determines the gas mixture velocity for a given flow rate and stream density.

Medium efficiency cyclones on fertilizer dusts usually operate well with inlet velocities between 2600 and 3500ft/min. for air at standard temperature and pressure. Corrections are made for operating temperature and pressure, including altitude and gage pressure corrections. Larger cyclones designed for lighter particles operate with lower inlet velocities ranging from about 2400 to 3500 ft./min. @ st&p. Velocities can be pushed to about 3500 ft/min. @ st&p., provided that turbulence does not suddenly cause excessive material loss to the overflow stream leaving the cyclone.

Cloth Filter Dust Collectors

Cloth filter dust collectors or bag houses are capable of 99.9% collection efficiency on fine particles and the collected material is kept in dry form. Several bag cleaning methods are used, including high pressure pulse jet, low pressure reverse flow, and mechanical shaker.

A bag house consists of an inlet duct arranged to introduce and distribute dust laden air smoothly into the dirty air compartment containing the bags with a minimum of pressure loss and abrasive effect on the bags, with a collection hopper for collected dust below and a clean air plenum above. A tube sheet separates the dirty air compartment and the clean air plenum, and air passes through the filtering cloth to the inside of the bags and then upwards through openings in the tube sheet to enter the clean air plenum.

Air volume to cloth area ratios must be kept to appropriate values for each material application and bag material. A ratio of about 5 ACFM per square foot which is equivalent to an average velocity of 5 feet per minute through the filter cloth is a conservative value for a typical fertilizer application with standard felted polyester bags. Higher values can be used for light dust loadings and favorable conditions, and lower values may be wise on very heavy dust loadings and difficult conditions.

Cloth filter dust collectors can be very large for large gas streams and initial capital costs, maintenance costs, and operating costs can be substantial. Large units also occupy a substantial amount of floor space and building volume.

Dirty gas entry must be carefully designed to minimize abrasive wear on the bags and to facilitate efficient dust removal from the collection hopper.

Housings must be designed to withstand the design static pressure differential to atmospheric pressure (gage pressure), and should be protected with a good paint system or coating, or be made of an appropriate stainless steel.

Bag cages should be either well painted, coated, or of stainless steel. Clamps should be stainless. Bags must be chosen for possible corrosive conditions, abrasion resistance, operating temperature, humidity, filtration characteristics, operating pressure drop, cleaning method, and dust release properties. Woven monofilament cloths are usual for shaker type collectors and felted cloths are usual for reverse jet collectors. Bags will shrink if overheated, and fabrics are sometimes preshrunk to minimize this. Felted bags may also be scorched to improve dust collection performance.

Bags are cleaned frequently on a set timing schedule by shaker mechanisms, or by timed pulse jets of dry compressed air.

The formation of condensate on collector walls and bag surfaces is a frequently encountered problem. Insulation, auxiliary heating, and careful design for operation at at least 50 Degrees Fahrenheit above the dew point inside the bag house are advised. If the bags become damp or wet, they will blind over and no longer pass the required air volume.

If this condition is detected early enough, sometimes it is possible to recover by stopping the material feed, possibly increasing the gas temperature slightly (if possible without damaging bags), and continuing to pulse the bags for about 15 minutes. An adjustment to increase the pulsing air pressure may help, and increasing the frequency of pulsing may be necessary to prevent recurrence of the blinding.

If the collector is located outside, the housing and support structure must be structurally designed for dead loads, live material loads including possible accumulation of excess solids material in collector and ducts, and for wind and earthquake loads.

Pulsing air should be dry compressed air at specified pressure and volume. Adjustment of air pressure and pulse timing is done at start-up to keep bags sufficiently clean while minimizing use of compressed air and flexural stress and wear on bags.

In addition to insulation, auxiliary heat and warm air circulation for stand-by may be advisable for some installations.

A planned procedure for start-ups, normal shut downs, and recovery from upset conditions to try to clear fouled bags can help to keep a bag collector functioning continuously. Prior to start-up, the air handling system should be turned on and the system warmed up thoroughly before material is introduced. At shut down, the material flow should be stopped and the system emptied, then the heat turned down or off and the system cooled and filled with cool dry air which will contain less moisture, and finally, the exhaust fan may be turned off.

Wet Scrubbers

Like cyclones, scrubbers can achieve high efficiencies but 100% collection is rarely possible or economical. The ecological and economic problems of water availability and the disposal of contaminated effluents from scrubbers are often the determinants that drive scrubber system design.

A scrubber system design for a fertilizer application is immediately governed by the chemical and physical characteristics of the process being served. The fundamental process requirement may be an absorption, an adsorption, a dissolving, simple physical wetting, or a chemical reaction. The scrubbing process may be an easy one or it may be quite difficult. Liquid temperatures, chemical concentrations, vapor pressures, and chemical equilibria often enter into the design and for these reasons, scrubber design should not be separated from the process design. There are a number of designs with special features and the choice therefore requires careful engineering.

Functions in a scrubber include entry, wetting or spraying, mixing, coalescing, separation, and dewatering. The goal is to thoroughly wet and collect particulate and absorb gaseous pollutants, separate the liquid effluent from the gas stream, and remove as much mist as possible from the leaving gas stream, using as little energy and water as possible commensurate with doing a good job. Corrosion, scale build-up, and fouling with solid deposits are to be expected and the design must provide for corrosion resistance and means of cleaning.

Dewatering is important because water droplets can severely erode fan blades. Initial dewatering of large drops can be done by inertial separation, but fine droplets are taken out by filtration in mist eliminators.

A typical application might utilize a two stage design if the entering gas stream contains a lot of fine micron and sub-micron particulate or if it is hazardous. The first stage could be a flooded downflow venturi type of medium or high pressure drop. Adjustable venturi types with a lot of wetted steel surface area to take advantage of the higher efficiency of collisions between fine particles and the wetted steel surfaces are good for very fine particulate and aerosols.

High velocity increases turbulence in the venturi throat, which increases particle to particle collisions between very fine solid particles and fine water droplets. Velocity in the throat could be 15,000 to as high as 25,000 ft/min but the pressure drop and fan horsepower become very high for the higher velocities.

The shape of the venturi could resemble the top surfaces of two airplane wing airfoils facing each other and arranged so that the clearance in the throat can be adjusted to reduce or increase the width of the opening to take advantage of as much pressure drop as the exhaust fan can deliver. Down flow venturis handle wetted solids and sludge fairly well and are easier to clean than packed towers. This type of scrubber has been used to scrub acid fume, fine particulate, and ammonium chloride from granulator stacks.

The second stage in this case could be a wet sump cyclonic tower with irrigated trays or saddle type packing. In a second stage, solids build-up should be much less than in a first stage. If possible, the design should provide for cleaning in place.

It is almost always necessary to minimize total water consumption because of both fresh water availability and cost and disposal problems. The ideal situation is a zero discharge system in which the scrubber effluent can be utilized in the process.

Examples of Integrating Process and Scrubbing For Near-Zero Loss of Contaminants in Waste Water or Emissions to the Atmosphere

In DAP plants, escaping pre-neutralizer and granulator ammonia can be scrubbed with a weak phosphoric acid solution and returned to the process as ammonium phosphate. Excess water in the system can pose problems for the plant in successfully drying and cooling the product and in maintaining grade analysis specifications.

Plants emitting fluorine as silicon tetrafluoride and acid mist from normal superphosphate manufacturing operations have economically scrubbed and cleaned the air leaving the acidulation units, producing hydrofluosilicic acid which, after being filtered in two steps to remove amorphous silica and heavy metals, can be sold to municipalities for use in fluoridating drinking water. Gelatinous SiO_2 contaminated with remnants of the acid are left on top of the sand filter and must be removed for disposal. Periodically, the sand and metallurgical grade coal used for filtration must be replaced.

Capture of Fugitive Dusts

An obvious approach to pollution control is to capture and treat fugitive pollutants that have previously escaped, but a frequently better approach is to provide machines and processes that can prevent the generation and escape of pollutants in the first place.

When technically and economically possible, it is logical to attempt to control dust generation at or near its sources before it escapes into the atmosphere. In the case of fugitive dust, networks of hoods and pickups connected by ducts can collect and transport dusts to central collectors while keeping machine housings under negative pressure to minimize outward leakage. In all cases provisions for disposal of the collected material must be made.

An addition to a large coal desulfurization plant is under construction in North Dakota which will produce fertilizer grade granular ammonium sulfate from SO_2 waste gases. The dust collection system combines dryer and cooler streams with a large number of specialized dust pick-up stations into one large completely integrated dust collection unit with a cloth filter dust collector.

Housings of dust generating equipment are being fitted with dust removal hoods or nozzles and connected into the system of ducts leading to the collector.

Open hoods can be used when necessary but are less effective in capturing dust.

It has also been possible to draw dust laden air from other dust producing units such as vibrating screens or elevators into dryer or cooler dust collection systems.

Integration of Process Design and Pollution Control

The chemical and mechanical processes are inextricably intertwined with the pollution control process and for this reason I honestly believe that the best place to work on pollution control endeavors is directly with plant and process designers who can deal with both the process and pollution control aspects of an operation.

Any engineering decisions should always involve consideration of technical feasibility and effectiveness, total cost versus benefits, and safety.

Selected References

Alden, John L. *Design of Industrial Exhaust Systems*, 3rd. Ed., Industrial Press (1959).

Dallavalle, J. M. *Micrometrics: The Technology of Fine Particles,* 2nd. Ed., Pitman (1948).

Baretincic, Joseph. "Environmental Regulations," in Nielsson, Francis T., Ed: *Manual of Fertilizer Procesing*, Marcel Dekker, Inc. (1987).

Coulson, J. M. and J. F. Richardson. *Chemical Engineering,* Vol. Two, 2nd Ed., Pergamon Press (1968).

Dickerson, Richard E., Harry B. Gray, and Gilbert P. Haight, Jr. *Chemical Principles,* 2nd Ed., W. A. Benjamin, Inc. (1974).

Fuchs, N. A. Tr. by R. E. Daisley and Marina Fuchs, Ed. by C. N. Davies: *The Mechanics of Aerosols,* Rev. Pergamon Press (1964).

Green, Don, Ed. *Perry's Chemical Engineers' Handbook*, 6th Ed., McGraw-Hill Book Co. (1984).

Hansen, Arthur O. and Robert J. Danos. *The Design and Selection of Scrubbers for [Fertilizer] Granulation Plants,* Gulf Design Division, Badger America, Inc. (1980).

Jorgensen, Robert. *Fan Engineering,* 7th Ed., Buffalo Forge Company (1970).

Lange, Norbert A. *Handbook of Chemistry,* McGraw-Hill Book Company (Various Editions)

Lapple C. E. *Dust and Mist Collection,* p. 1013-1050 In Perry, John H., Ed: *Chemical Engineers' Handbook,* 3rd. Ed., McGraw-Hill Book Co. (1950).

Marchello, Joseph M. and John J. Kelly, Eds. *Gas Cleaning For Air Quality Control,* Marcel Dekker, Inc. (1975).

Nonhebel, G., Ed. *Gas Purification Processes,* George Newnes Limited (1964).

Rader, Robert G., Michael Mutsakis, Koch Engineering Company, Inc. and F. Grosz Roell W. Maugweiller, Sulzer Brothers, Ltd. *Co-Current Absorption/ Scrubbing With Static Mixing Units,* Koch Engineering Co., Inc. (1988).

Robinson, Robert E. *[Dust Control in] Storage and Transport of Solid Fertilizers* in Hodge, Charles A. and Neculai . Popovici: *Pollution Control in Fertilizer Production,* Marcel Dekker, Inc. (1994).

Robinson, Robert E: *Variable Throat Venturi Scrubber System for Fine Particulates,* Robert E. Robinson and Associates

Robinson, Robert E. *Two Stage Venturi Scrubber System for Silicon Tetrafluoride,* Robert E. Robinson and Associates

Seidell, Atherton and William F. Linke. *Solubilities of Inorganic and Metal Organic Compounds,* 4th Ed., Vol. 1 and three 3rd. Ed. Volumes, D. Van Nostrand Company, Inc. (1958).

Strauss, W. *Industrial Gas Cleaning,* Pergamon Press (1966).

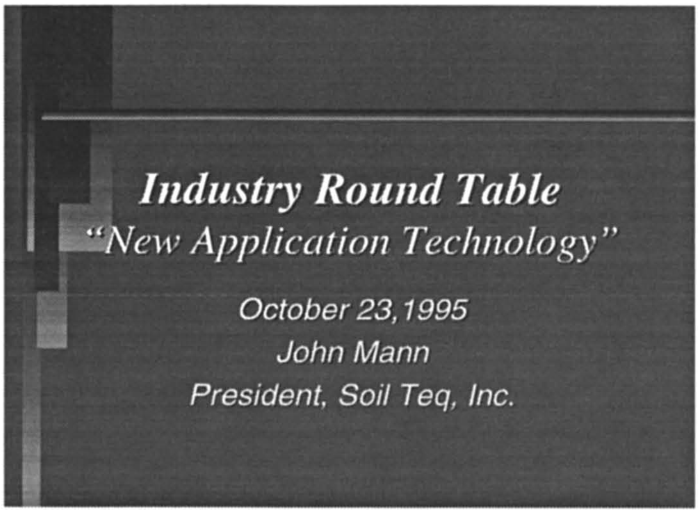
Szekely, Julian, James W. Evans, and Hong Yong Sohn. *Gas-Solids Reaction,* Academic Press (1976).

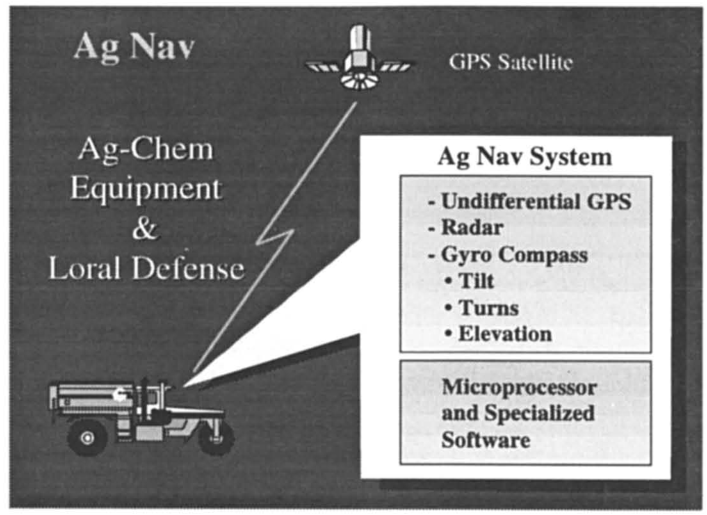
Valenzuella , Diego P. and Alan L. Myers. Adsorption Equilibrium Data Handbook, Prentice Hall (1989).

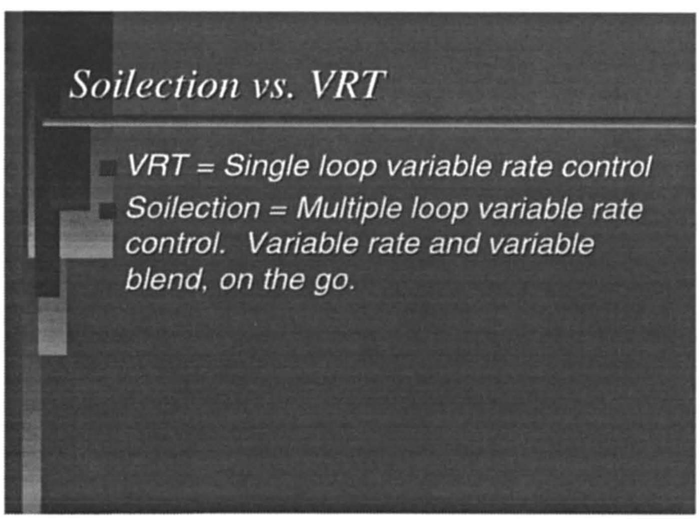
New Technology forFertilizer Placement and Application

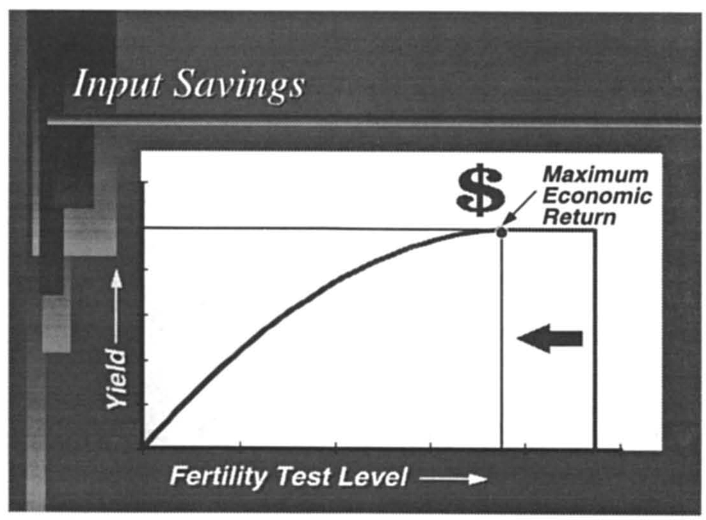
John Mann
Soil Teq, Inc.

Following is the overhead slide presentation as presented by Mr. Mann.

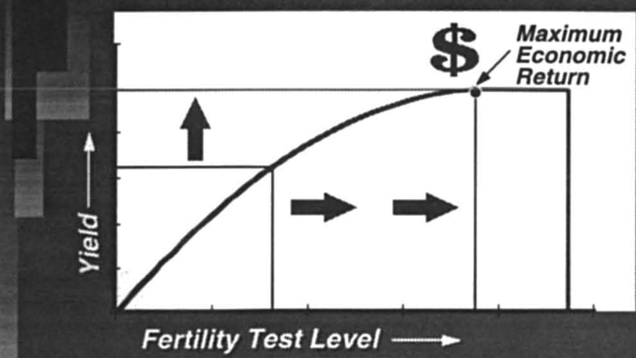








Increase Gross Returns



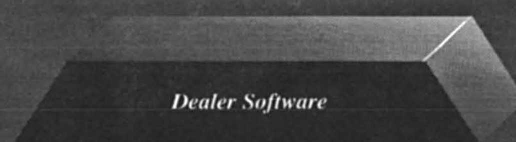
Soilection Geographical Information System (SGIS)

- Full Featured GIS Package
- Tailor-Made For Our Industry
- Automated Map Creation
- Easy To Use
- Database Functions
- Expert System Generation
- Open Architecture

Yield Monitors: "Where do they fit?"

- Yield Monitors are the rolling report card
- They, "close," the precision loop
- Yield monitor data by itself is not enough information to make decisions
  - Must be combined with: Soil type, fertility grid samples, slope, water holding capacity and other data to get the true picture

What is SGIS?



Yield Monitors: "Where do they fit?"

- Multiple years of yield data will be needed to give confidence in the information:
  - Need to remove abnormalities like:
    - Insect pressures
    - Herbicide problems
    - Seed Variety differences
    - Impacts of Tillage practices
    - Different Cropping Practices
- The only way to do this is with multiple years of data in combination with other crucial data

Dealer Software

The Dealer Software is the only piece of SGIS that the dealer actually sees. It is the base of SGIS

- Imports Data.
- Stores Data at Dealer Site.
- Creates Recommendation Maps.
- Prints Maps.
- Quality Control Checks.

Communication Software

This "behind the scenes" software consists of three parts: data extraction, dial-up, data input.

- Tracks all maps created in SGIS for upload.
- Dials modem when necessary.
- Sends data to Windows NT File Server.
- Retrieves account data from SQL Server.
- Error Tracking & Logging.

Who's Who in Dealer Software?

Accounting | Chemical Labels | Inventory | Point of Sale | SGIS

DEALER SOFTWARE SUITE

Central Database: SQL Server

This is the upload data repository.

- Located in Minnetonka, MN.
- Stores Customer Profiles.
- Stores All of the Data used to Create Maps.
- Linked to All Customers through Wide Area Network of Modems

"Quality Control & Value Added"

Data Analysis

The Data Analysis, although shown as a single piece on the pyramid, is really a collection of custom and commercial software, the expertise of scientist and engineers as well as our customers.

- The information tool of the future
- Analysis of Data within a Layer
- Analysis of Data across Layers
- Mathematically updated Soil Samples
- Gross Margin Maps
- Add Value to the Information

Why collect the data?

- Maintain a level of quality and integrity in the program.
- Value added information products derived from the specific data, offered back to the specific sender.
- Enhanced expert system derived from the general expertise gleaned from the database.

What is Data Analysis?

- Each time a map is made, the software extracts the raw data and sends it to the central database
- Other forms of information (Yield Monitors) will be added to the database
- Information will be analyzed for relationships (ie. grid soil sample, soil build-up factors, crop removal factors and yield from a yield monitor)

What is Data Analysis?

- Analysis work is done at the central site
- Data will be confidential and not sold
- We claim no ownership to the data
- Data will be used to answer the following:
  - How well did the program perform last year?
  - What will we change based on last year"(s) data?

What is Data Analysis?

- Other uses:
  - Gross Margin Maps
  - Intelligence Guided Sampling
  - Efficiency comparisons (DHIA)
  - Refinement of the Expert System

What do I get for the $.50/Acre?

- SGIS is furnished.
- Training and support is furnished.
- Full feature GIS for multi-layer analysis.
- Incorporates dealer's own recommendations - flexible.
- Raw data is extracted
- 4 minutes per map performance

What do I get for the $.50/Acre?

- Quality control, integrity of program maintained.
- Dealer's recommendations are proprietary and confidential.
- No ownership of data is claimed.
- Data will not be sold to a third party.
- Open architecture.

What do I get for $.50/Acre?

- Add value to data.
- Dealer's own data is on site.
- Large data analysis tasks, programming, computer, and human resource costs shared by users.

Data Management & Confidentiality Agreement

Contract Specifics:

- Data collected will not be sold to a third party.
- Recommendation equations are proprietary and confidential property of the fertilizer dealer.
- Soil Teq accepts no liability for the recommendation equations.
- Soil Teq will add value to the data.

What is a Confidentiality & Data Management Contract?

- Protection for the customer's data.
- Protection for the customer's recommendations.
- Spells out how data will be transferred.
- Releases Soil Teq/Ag Chem from liability.
- Insures Quality Control, & Integrity.

"What's the payoff for the grower?"

Contract Specifics:

- Specific raw data will be collected in the process of making a map with SGIS.
- Raw data will be stored in the central system.
- Collection is to insure quality and integrity of SGIS maps.
- Data collected belongs to the dealer/ farmer not Soil Teq.

University of Minnesota

Treatment	Yield Bu/A	Net $ Increase
Conventional	133	0
Variable Fertilizer	139	$5.00/A
Variable Herbicide & Fertilizer	145	$20.00/A

Dr. Pierre Robert
Lamberton Experiment Station

University of Minnesota

	Variable	Conventional
Yield (Bu/Ac)	132	119
Moisture (%)	26.6	27
Add'l Charges ($)	7	0
Benefit ($)/Ac	23	

$23.00 / Acre Net Advantage

Dr. Daryl Buchholz
University of Missouri

- "We strongly believe variable rate fertilization shows promise as a practice that will be profitable."
- "Nitrogen management based on a, "useful," yield potential map, combined with P, K, and lime applications based on nutrient grid sampling appears to offer the most potential for yield improvement and efficient fertilizer use."
- "We believe profitability will be greatest for fields that contain soil of contrasting texture (yield potential) and low soil test P & K levels."

Dr. Pierre Robert
University of Minnesota

- "Covariate analysis of the strip means using expenses as a covariate showed an <u>85% probability of receiving a greater net return using variable rate applications verses the conventional uniform rates</u>."

American Crystal Sugar
Soilection Impact On Sugarbeets

Measurement	SOILECTION	Conventional
Tons / Ac	18.7	18.0
% Sugar	17.9	16.6
Sugar-lb./Ac	6171	5418

$141 / Acre
Difference

Dr. Daryl Buchholz
University of Missouri

- Field #1: Variable spreading of an 80/ Acre field yielded $40.89 per acre.
- Field #2: Variable spreading of an 82.2/ Acre field yielded $16.38 per acre.
- Field #3: Variable spreading of this field yielded $9.14/Acre

Summary

- It will not make a poor farmer a good farmer.
- It will make a good farmer a better farmer.
- Environmentally it makes sense.
- Implemented correctly, it can be profitable for the dealer, consultant and producer.

The Future of Controlled Release Fertilizers in Agriculture

William L. Hall
VIGORO Industries, Inc.

Good afternoon. In organizing my presentation I felt that the old "where we were, where we are, where we are going" approach fits well with this subject.

We will discuss a very short history. Most of you are aware of this history; however, in order for us to view this segment from the same perspective, I will spend a couple of minutes on "where we were". Next I will spend some time discussing "where we are"—specifically new products, prospectives, and current cooperative efforts to address methodology and regulatory issues. Finally, I will attempt to give my perspective on where "we are going" and how we can have an affect on how we get there.

I

To begin with, a short history lesson. a couple of brief definitions are in order. A good definition of "agriculture" is critical to our viewing this issue from the same perspective. We could say growing turf on a golf course in Florida is an agricultural crop, but we won't. We could say 100 acres of strawberries in southern California is an agricultural crop, but we won't. We could say 500 hectares of rice paddy in Japan is an agricultural crop, but we won't. why? Use of controlled release technology is already an accepted practice by most fertilizer users in these areas. For our purposes we will look at three crops in two different climatic areas. First large scale citrus production in Florida. Then "no till" corn and soybeans in the midwest. I would hope that there is no argument that this truly fits our perception of "agriculture".

Now back to our history lesson. This will be very brief. Mind and memory experts agree that optimizing retention is aided by segmenting and correlating data with specific images. This is critical to my thinking also, therefore, I have created a little chart to help me segment and correlate what has happened to date.

up to 1959	Solubles and "natural" organics
1960's	Scu - sulfur coated ureas
1970's	Synthetic organics - urea aldehydes
1980's	PCU - plastic coated ureas
1990's	PCSCU and inhibitors - Tricoat, DCD
1990's	Ag improvements - no till + precision ag

II

"Where we are now" is quite easy for me to talk about because of my involvement in several aspects of developing technologies. Some of these are internal within Vigoro, others are competitive products. However, my involvement in a group that met here earlier in the week is where my perspective is broadest — the controlled release task force.

This is the controlled release task force make up and subcommittees.

Slow Release Task Force Subcommittee Organization

Methodology

Bill Hall,	Chair	Vigoro Industries
Ed Huber		TFI
Dave Terry		Ky Dept. of Ag.

Labeling

Gary Braun	Chair	Mn Dept. of Ag.
John Detrick		Pursell industries
Joel Padmore		NC Dept. of Ag.

Enforcement

Dale Dubberly	Chair	Fl Dept. of Ag.
Dick Harrell		Terra Nit.

New Products/ Concepts

John Detrick	Chair	Pursell Industrie
Joel Padmore		NC Dept. of Ag.
Allen Sutton		IMC Global

Policy	Task Force Chair	
Wilbur Frye	Chair	Ky dept. of ag.
Bill Hall		Vigoro Industries
Whit Yelverton		TFI

The task force was formed jointly by AAPFCO and TFI as a result of present and future needs for regulation and improved methodology.

This policy statement excerpt shows the direction of the task force.

The policy statement begins by simply explaining why we are doing what we are doing. It says "AAPFCO'S model legislation is currently inadequate for slow-release fertilizers and stabilized products. These products improve the efficiency, minimize potential nutrient losses, and help protect environmental quality. The use and market share of these products are expected to increase. affirming AAPFCO'S goal to provide consumer protection while encouraging free commerce." The policy statement makes several recommendations. it recommends the adoption of the term "*efficiency design*" to describe these products. I can tell you this has not been an easy term to agree upon. The policy also recommends the adoption of the term "*slow-release*" to describe fertilizers that release nutrients slower than reference soluble materials, that is, coated or occluded, water-insoluble, and slowly available water-soluble materials. It further recommends adoption of the term "*stabilized*" to describe products with added substances that slow transformations and extend the time of availability of the nutrients, e.g., the nitrification inhibitors and other nitrogen stabilizers and grease inhibitors.

Our method goals are outlined below.

Goals of new method for extraction and analysis of *efficiency design fertilizers*

1. Must be able to categorize materials in a tree structure with logic and for computer ease.
2. Status of current materials will not change significantly.
3. Can be run in an analytical laboratory.
4. Can be run in seven days, preferably less.
5. Would be able to be performed by technicians using available equipment, thus gaining wide acceptance.
6. Would be applicable to a wide variety of blended materials.

The variables effecting release & extraction include:

- time
- temperature
- solvent
- agitation
- matrix affects
- equilibrium (solvent volume)
- biological population & type

Other possibilities:

- placement
- sampling & sample size

Material category divisions are outlined in Figure 1.

Direct measurement of inhibitor materials will be by HPLC. Reference sample groups are set up as seen in Figure 2.

A search of current methodology revealed the information in Figure 3.

Extraction results are summarized in Figure 4.

So why all the attention to these products now? Because technology and environmental pressures have moved us ahead faster than regulatory functions or methodology has been able to adapt. As an illustration, I will show the crop examples of "agriculture" I alluded to earlier.

First citrus in central florida is under a time table to produce bmp's for citrus production on "at risk" or high leaching soils. Industry, environmental and state officials have met and are working toward this goal. Interim measures being proposed are listed in Figure 5.

Nitrogen interim measure for Florida citrus 10-20-95

Maximum nitrogen (n) rates per calendar are provided in the following table. Available nitrogen from all sources (except foliar applied formulations) including dry granular, controlled release, suspension, solution, manure, compost, sludge, municipal effluent, or any other source applied to the grove must be included in calculating pounds of n per year.

For purposes of this interim measure, the contribution of available nitrogen from purely natural organic sources applied during the calendar year shall be 50 percent of the total nitrogen content of the source. The total nitrogen content of the natural organic product should be determined from either a guaranteed or residual analysis provided by the manufacturer or distributor, or from Appendix B.2 in the University of Florida publication, sp 169, *Nutrition of Florida Citrus Trees* (1995).

Application rates, placement and timing.

For young non-bearing trees, select a rate in the lower part of the range if there are more than 220 trees per acre, or if the site is newly converted from pasture or vegetable production. A minimum of four applications of dry fertilizer, 10 applications by fertigation, or one application by controlled-release formulations is required for non-bearing trees. For bearing trees producing less than 500 boxes per acre, rates of nitrogen in the low to mid range are encouraged. A minimum of two applications per year is required for bearing groves receiving up to 150 pounds of nitrogen per acre. Bearing groves receiving more than 150 pounds of nitrogen require a minimum of three applications per year. Total nitrogen applied per acre in a block with both bearing and non-bearing trees may not exceed the range for bearing trees. Total nitrogen applied per acre in a bearing mixed variety block may not exceed the range for the predominant variety. Direct fertilizer application to the root zone. The application of at least half of the annual fertilizer nitrogen prior to the rainy season is encouraged. Minimize application of soluble nitrogen sources during the summer rainy period.

Other considerations

IFAS recommendations for nitrogen rates and management are provided in the University of Florida IFAS extension publication sp 169, *Nutrition of Florida Citrus Trees*. This publication describes the benefits of leaf analysis for adjusting fertilizer programs, the advantages of increasing the number of fertilizer applications and reducing the amount applied per application, and the importance of irrigation management in reducing nitrogen leaching.

As can be seen, there is a definite incentive to use controlled-release or input fertilizer products.

Next, some data on corn and soybeans in university testing at purdue. (See Figures 6-10).

This shows that the economics of these products are finally favoring the new technology. The need to regulate and monitor is here now.

Sound methodology is the key, its goals must be our focus.

III

Where we are going. Historically two courses lead to change in our industry. Each course has a critical point.

Northerly course:

- perception of need
- research
- education
- large scale economic success
- credibility
- communication
- imitation

Southerly course:

- education
- media attention
- public perception
- politics
- legislation
- enforcement
- compliance

Hopefully, the critical point in the northerly course is demonstrated by the corn and soybean data above. We are at the critical education step.

Unfortunately the citrus example is starting in the middle of the southerly course and at its critical step, legislation. Although it is at hand, quick action by industry and the department of agriculture may yet prevent legislation without education. however, this is a real danger and threat to agriculture and our industry. Education, not only within industry and agriculture, but also of the public and legislators is a key for determining at what point the process begins and which hemisphere is navigated.

Who is responsible for education?

It should be the people in this room.

Who charts the course of change in our industry?

The captain!

Will we be the captain or a passenger on future voyages?

Figure 1.

Efficiency Design Fertilizers Category Division

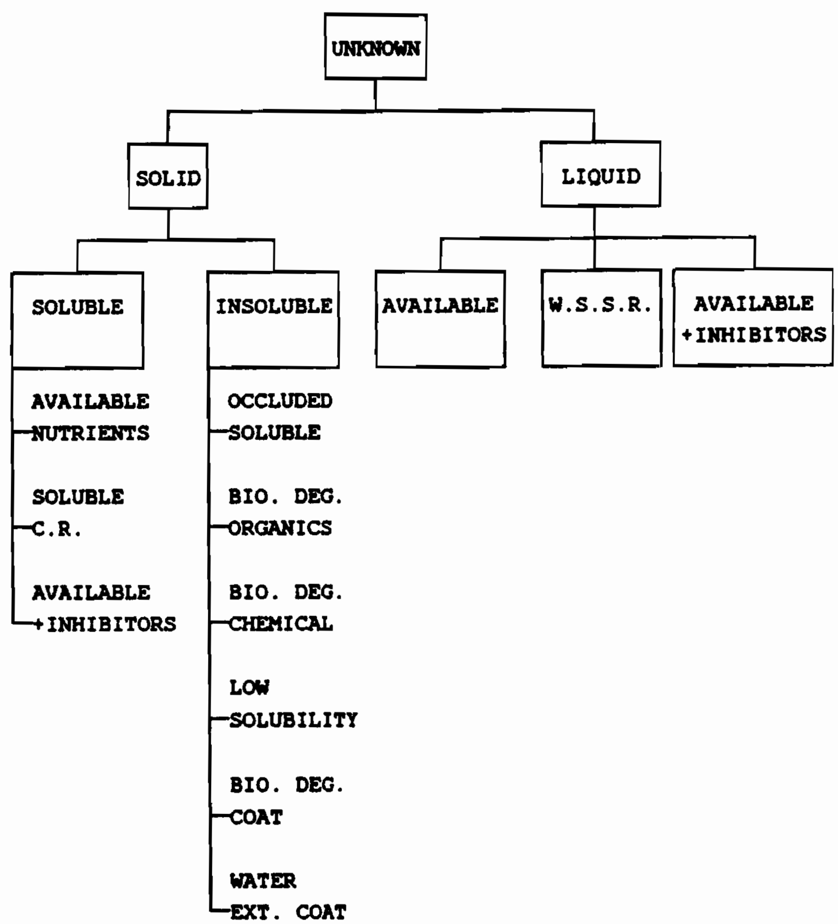


Figure 2.

PROPOSED MATERIAL POOL FOR "EFFICIENCY DESIGN" METHOD DEVELOPMENT

NUTRIENT	SOLUBLE	CONTROLLED RELEASE	EXTENDED RELEASE	STAB.
NIT.	UREA	SCU, IBDU, NITROFORM, MILORG. MDU-DMTU	+150DAY POLYMER COAT UREA, POLYMER COAT N-P-K	DCD NBPT N-SERVE
P_2O_5	DAP	S.C. DAP, MAGAMP	+150 DAY POLYMER COAT N-P-K	
K_2O	KCl	S.C. SOP, MAG POP	+150 DAY POLYMER COAT N-P=K	
SEC. Ca,Mg,S	GYPSUM	LIMESTONE	+150 DAY POLYMER COAT N-P=K + SEC.	
MINORS B,Cu,Fe, Mn,Zn	SULFATE	OXY-SUL.	+150 DAY POLYMER COAT N-P-K + MINORS	

MECHANISMS TO ACCELERATE RELEASE/MEASUREMENT

	WATER	WATER, HEAT, DIRECT MEAS., BIO./pH	WATER, HEAT	WATER, DIRECT MEAS.

Figure 3.

MATRIX CHART
CONTROLLED RELEASE PROCEDURES
FOR EXTRACTION AND ACCELERATION

SOURCE COMPANY	SCOPE	SOLVENT SYSTEM	TEMP. °C	SAMP/WATER RATIO	TOTAL SAMP/ WATER RATIO WATER CHANGE	SAMP FREQ	TEST
VIGORO	N-P-K-Mg PC & LS	WATER	~20°	5g/500ml	5g/2000ml COMPLETE	1H/1D 3D/7D	N-P-K MINORS
VIGORO	N-P-K-Mg PC & LS	WATER	40°	5g/500ml	5g/2000ml COMPLETE	1H/1D 3D/7D	N-P-K MINORS
SCOTT	SCU/ PCU	WATER	25°	25g/250ml	25g/1000ml COMPLETE	1H/1D 3D/7D	N
SCOTT	SCU/ PCU	WATER	60°	15g/150ml	15g/600ml COMPLETE	1H/1D 3D/7D	N-P-K
SIERRA	N-P-K PC	WATER	ROOM TEMP	4g/300ml	4g/600ml COMP. SAND	3D/10D X7D	N-P-K COND.
SIERRA	N-P-K PC	WATER	HIGH TEMP	20g/170ml	20g/170ml NO	15M/1H 2H	N-P-K COND.
ICI	SCU	WATER	LOW ?20°	12.5g/2500ml	12.5g/2500ml	1D/?	N
ICI	SCU	WATER	HIGH	40g/200ml	40g/200ml	1H/?	DENSITY
FISONS	PC N & N-P-K	WATER	25°	10g/500ml	10g/1000ml REFILLING	1D/7D	ISE/ICP
FISONS	PC N & N-P-K	WATER	HIGH	10g/200ml	10g/2600ml COMPLETE	1D/7D	N
AGLUCON	PC N-P-K	WATER	LOW	10g/800ml	10g/800ml NO	1D/7D	N-P-K & COND
AGLUCON	PC N-P-K	WATER	HIGH	10g/800ml	10g/800ml NO	8H/1D 2D/...	N-P-K & COND
PURCELL	PC N-P-K & SIZES	WATER	~22°	20g/100ml	20g/100ml NO	2H/3D 7D...	REF. I
PURCELL	PC N-P-K & SIZES	WATER	30°	10g/100ml	10g/100ml NO	2H/6H 12H...	REF. I
PURCELL	PC N & SIZES	WATER	60°	10g/100ml	10g/100ml NO	2H/6H 12H...	REF. I

Figure 4.

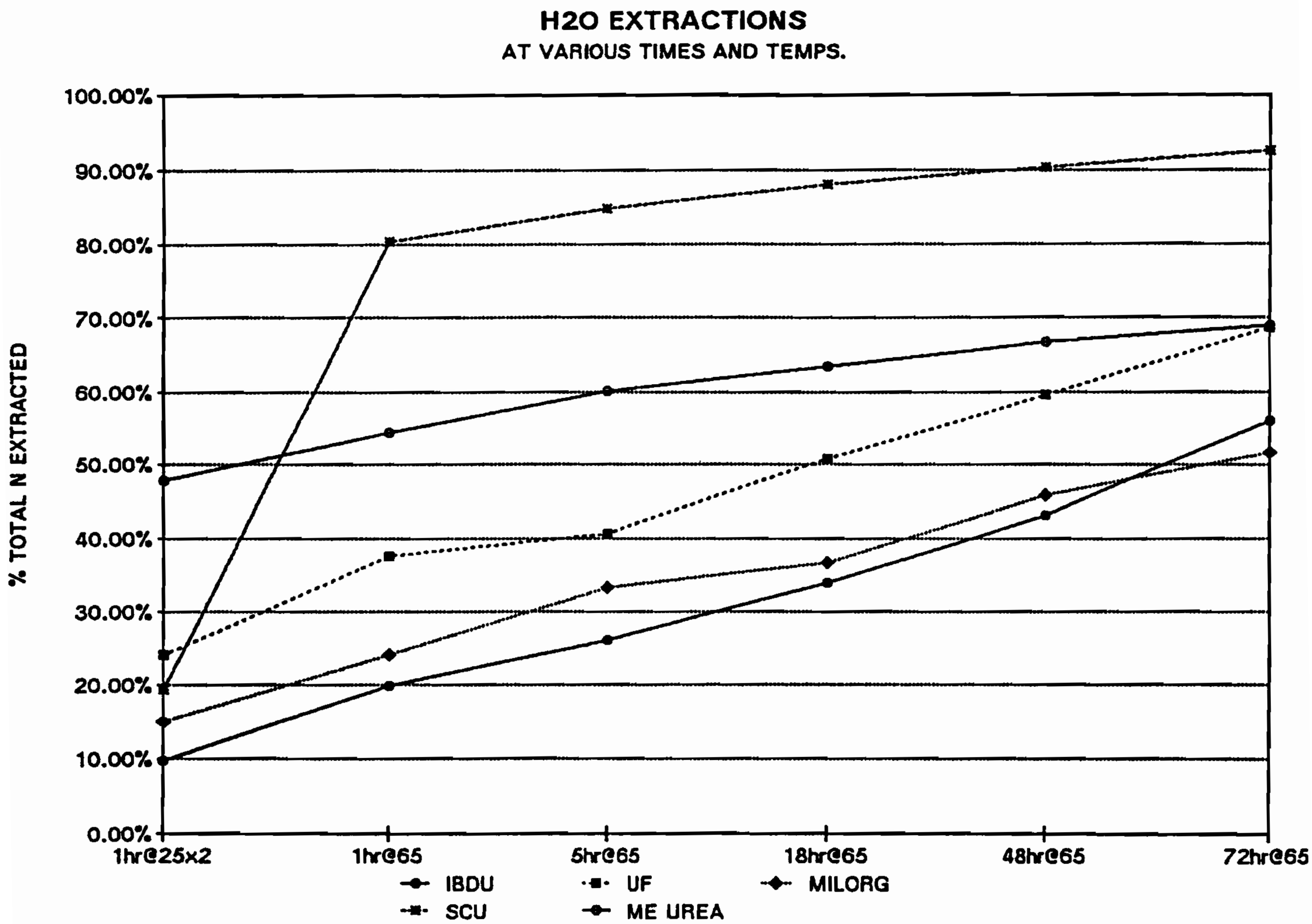

H2O EXTRACTIONS
AT VARIOUS TIMES AND TEMPS.
% TOTAL N EXTRACTED
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
1hr@25x2
1hr@65
5hr@65
18hr@65
48hr@65
72hr@65
IBDU
UF
MILORG
SCU
ME UREA

Figure 5.

YEARS IN GROVE	ORANGES	GRAPE-FRUIT	TANGELOS	MURCOTT	OTHER CITRUS
	---------- lbs. N/tree/year ----------				
1	.15-.30	Same	Same	Same	Same
2	.30-.60	Same	Same	Same	Same
3	.45-.90	Same	Same	Same	Same
	---------- lbs. N/tree/year[1] ----------				
4 or more	120-240	120-210	120-250	120-300	120-200

[1] Lower or higher rates may be required during a calendar year due to scheduling, horticultural, or climatic factors, but the average annual rate over 3 years may not exceed the maximum rate.

Figure 6.

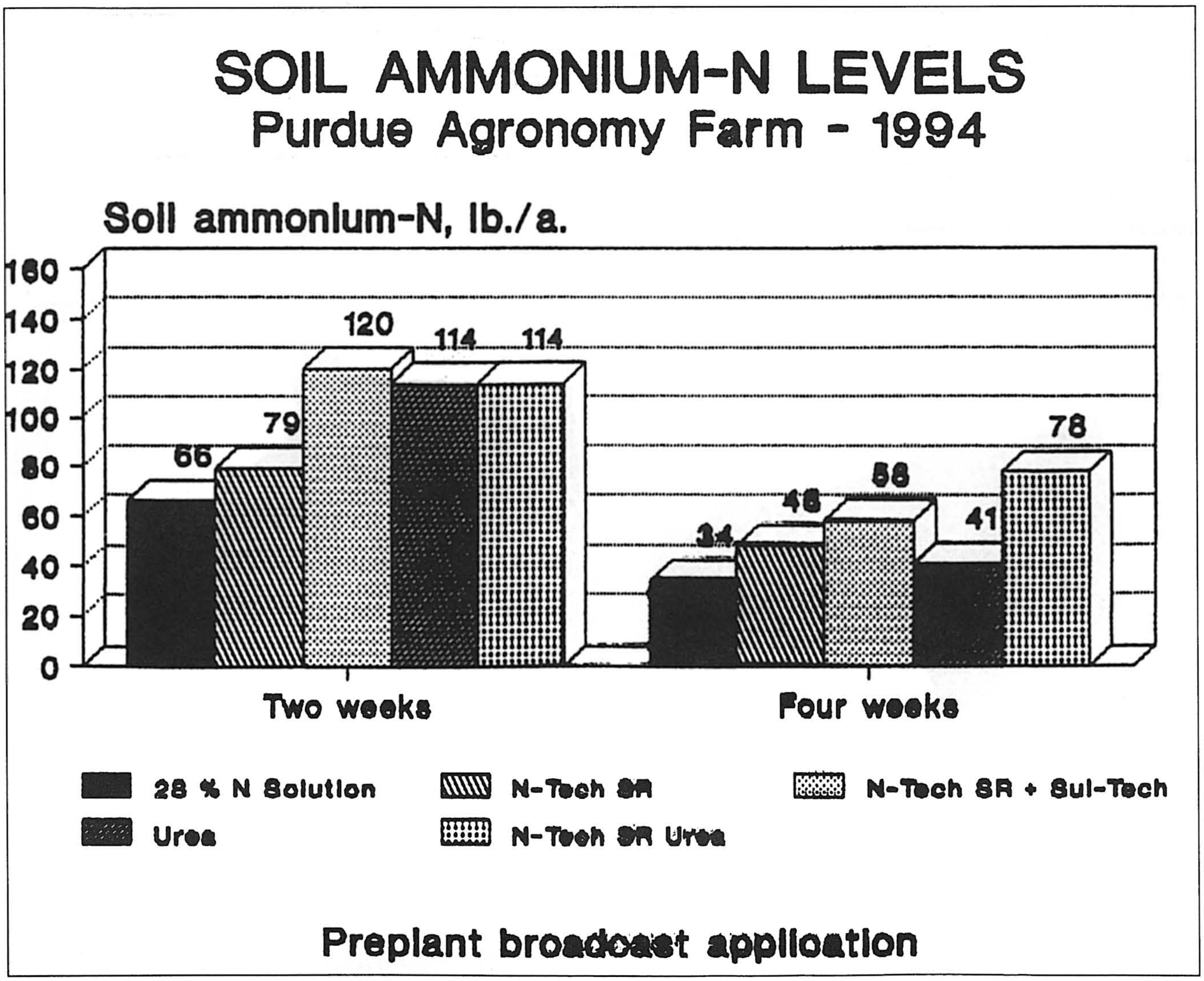


Figure 7.

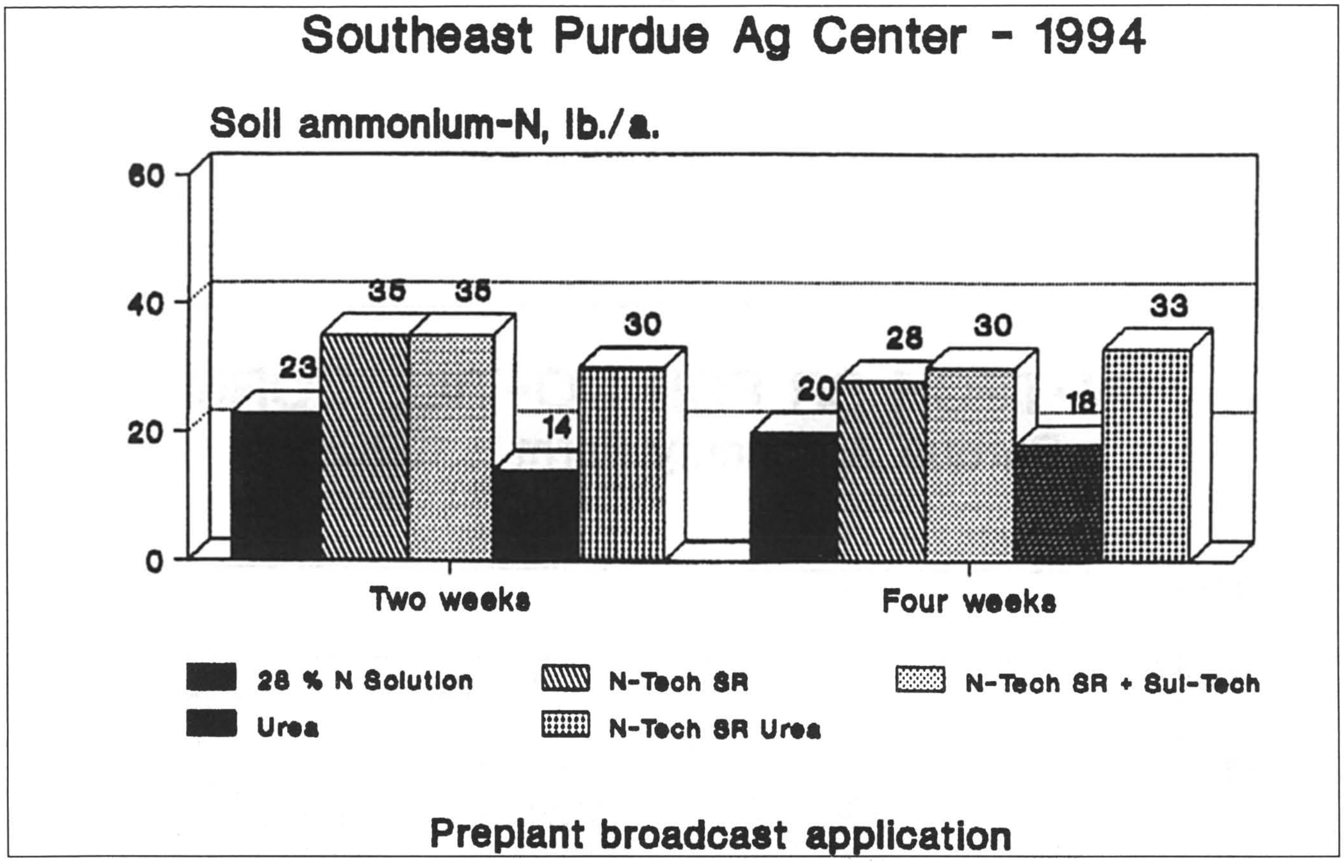


Figure 8.

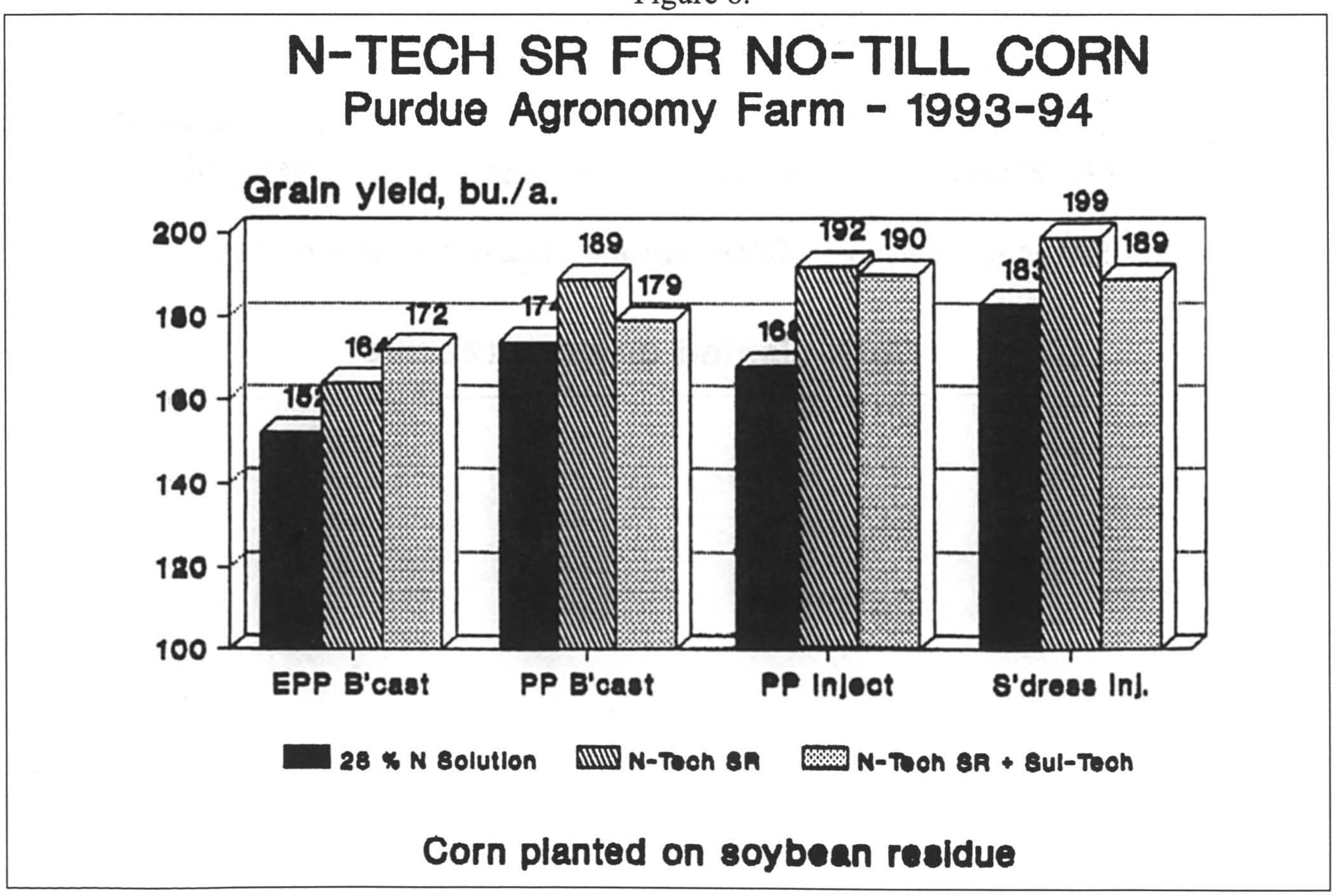


Figure 9.

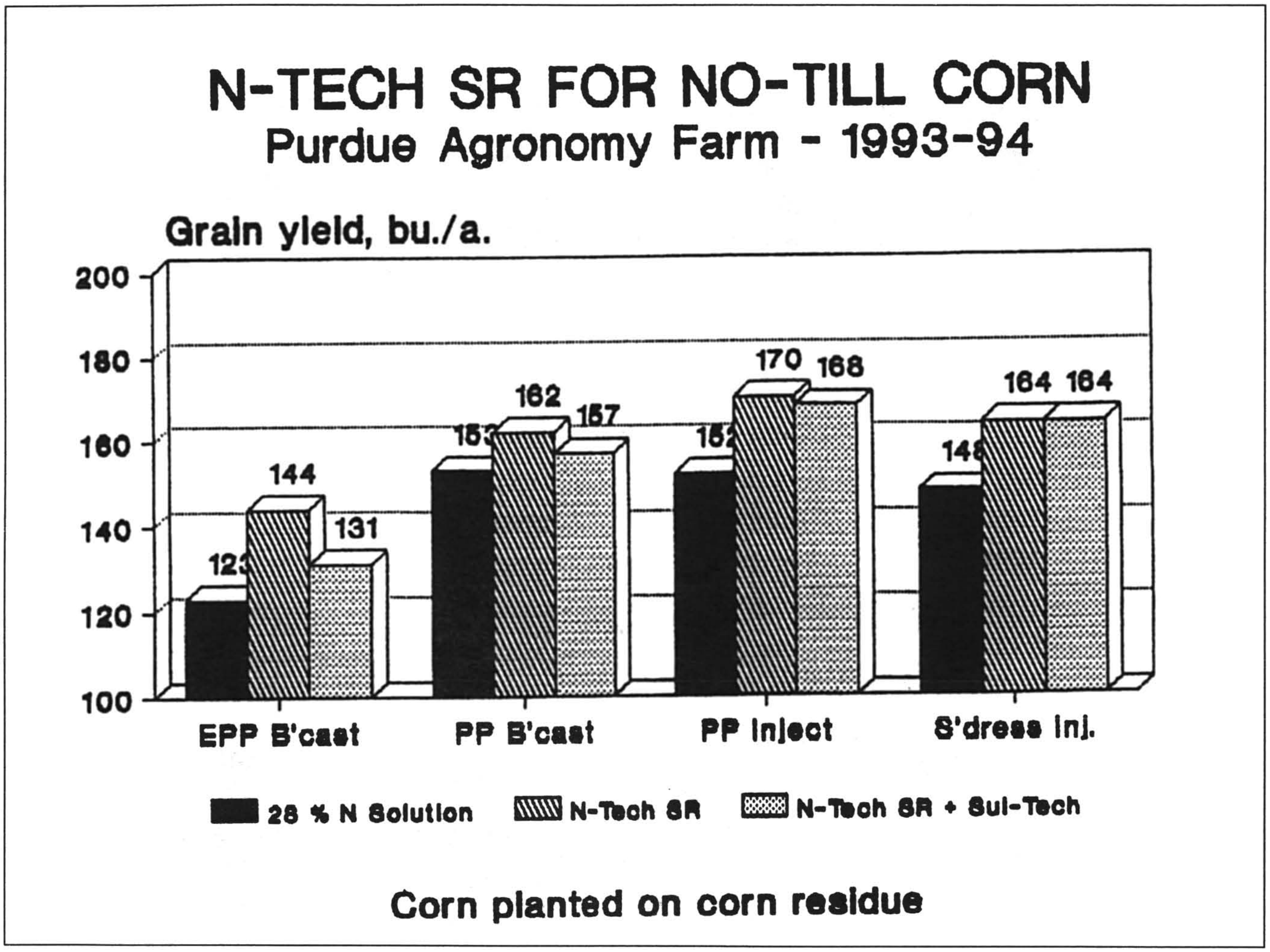

N-TECH SR FOR NO-TILL CORN
Purdue Agronomy Farm - 1993-94
Grain yield, bu./a.
200
180
160
140
120
100
144
131
162
157
170
168
164
164
EPP B'cast
PP B'cast
PP Inject
S'dress Inj.
28 % N Solution
N-Tech SR
N-Tech SR + Sul-Tech
Corn planted on corn residue

Figure 10.

ECONOMICS TO FARMER

PURDUE UNIVERSITY DATA

CORN PLANTED ON SOYBEAN RESIDUE

N-TECH SR PREPLANT B'CAST		UAN PREPLANT INJECTED	
GROSS INCOME:			
189 BU.	$ 396.90	168 BU.	$ 352.80
N FERTILIZATION EXPENSES:			
N-TECH SR	39.25	UAN	30.80
APPLICATION	3.50	APPLICATION	5.00
WITH HERBICIDE		HERB. APP.	3.50
NET INCOME AFTER N FERTILIZATION & APPLICATIONS	$ 354.15		$ 313.50

ECONOMICS TO FARMER

PURDUE UNIVERSITY DATA

CORN PLANTED ON CORN RESIDUE

N-TECH SR PREPLANT B'CAST		UAN PREPLANT INJECTED	
GROSS INCOME:			
162 BU.	$ 340.20	152 BU.	$ 319.20
N FERTILIZATION EXPENSES:			
N-TECH SR	39.25	UAN	30.80
APPLICATION	3.50	APPLICATION	5.00
WITH HERBICIDE		HERB. APP.	3.50
NET INCOME AFTER N FERTILIZATION & APPLICATIONS	$ 297.45		$ 279.90

BENEFITS OF N-TECH SR

- √ MAINTAIN SAFE AND CLEAN GROUND WATER.
- √ BETTER UTILIZATION OF APPLIED N.
- √ BETTER PLANNING TO MATCH N RATE WITH YIELD GOAL.
- √ DECREASE CHANCES OF GOVERNMENT REGULATION.

Wednesday, October 25, 1995

Tour of Rhone-Poulenc

Organized by:
Don Day
Norm Cook

At approximately 9:30 A.M., the attendees left the hotel by buses and proceeded to the Research Triangle Park to tour the Rhone-Poulenc pesticide research and development facility. After an introduction by Rick Roundtree, we broke into groups of eight to nine for a fascinating and educational tour of the screening and testing laboratories. All left with new insight and understanding of the almost overwhelming time and effort that is required to discover and develop new pesticides.

Wednesday, October 25, 1995

Tour of North Carolina State University Research Farm

Organized by:
Don Day
Norm Cook

At approximately 11:00 A.M., the buses took the group to the North Carolina State University Research Farm for an engaging on-site tour of their ground water contamination studies. This part of the tour was hosted by Dr. Eugene Kamprath and Dr. Wendell Gilliam of NCSU who explained the nature of the work and the results observed to date.

Thursday, October 26, 1995

Tour of PCS Phosphate

Organized by:
Don Day
Guy Whitaker

At approximately 8:30 A.M., the group departed the hotel and traveled to the PCS Phosphate Recreation Area where Mitchell Harris presented a video program which described the phosphate mining and chemical operations.

The group, under the direction of Pete Moffett and Charles Edwards of PCS Phosphate, then toured the mine where bucket wheel excavators and large draglines were observed. The tour group also visited the phosphoric acid control room and an operating DAP plant.

The Fertilizer Industry Round Table is most appreciative of the hospitality extended by staff members at Rhone-Poulenc, North Carolina State University, and PCS Phosphate Company, Inc.

FINANCIAL STATEMENT

NOVEMBER 7, 1994 TO OCTOBER 23, 1995

Cash Balance November 7, 1994		$ 31,063.63
Income November 7, 1994 to October 23, 1995		
Registration Fees – 1994 Meeting & Cocktail Party & Coffee Break Receipts	$ 10,472.60	
Sale of Proceedings	1,133.90	
Registration Fees – 1995 Meeting & Cocktail Party & Coffee Break Receipts	16,725.00	
Total Receipts November 7, 1994 to October 23, 1995		28,331.50
Total Funds Available November 7, 1994 to October 23, 1995		$ 59,395.13
Disbursements November 7, 1994 to October 23, 1995		
1994 Meeting Expenses (Incl. Cocktail Party)	$ 9,714.26	
Misc. Expenses Incl. Postage, Stationery, etc.	1,373.98	
1994 Proceedings	7,220.90	
1995 Meeting Preliminary Expense	1,355.31	
Directors' Meeting	1,457.28	
Advertising	0	
Total Disbursements November 7, 1994 to October 23, 1995		21,121.73
Cash Balance October 23, 1995		$ 38,273.40

Respectfully submitted,

Paul J. Prosser, Jr.
Secretary\Treasurer

Meeting Attendance 126