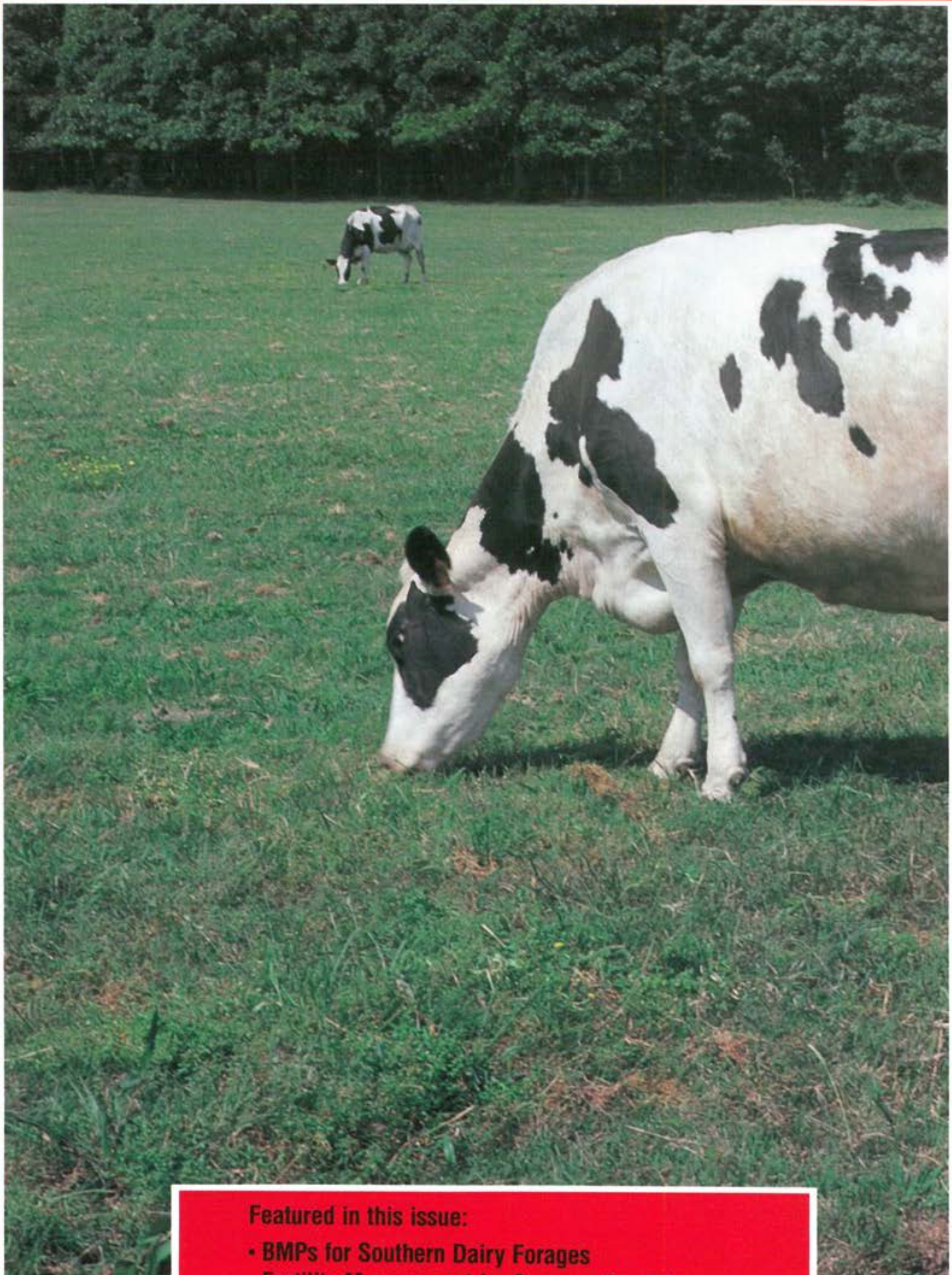
BETTER CROPS
WITH PLANT FOOD

Winter 1991-92



Featured in this issue:

- BMPs for Southern Dairy Forages
- Fertility Management for Conservation Tillage

BETTER CROPS With Plant Food

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Our Cover: Research in Texas shows that managing Coastal bermudagrass to increase the leaf-to-stem ratio can greatly improve the quality for dairy animals. Photo by Dr. J. Neal Pratt.

R.G. Connochie Elected Chairman, R.L. Latiolais Vice Chairman of PPI and FAR Boards of Directors

ROBERT G. CONNOCHIE, Chairman and President of the Potash Company of America, Inc. (PCA), has been elected Chairman of the Potash & Phosphate Institute (PPI) Board of Directors. He will also serve as Chairman of the Foundation for Agronomic Research (FAR) Board. **René L. Latiolais**, President and Chief Executive Officer of Freeport-McMoRan Resource Partners, is the new Vice Chairman of the PPI and FAR Boards.

"We are very pleased to have Bob Connochie and René Latiolais assume their new leadership responsibilities with the PPI and FAR Boards," said Dr. David W. Dibb, President of PPI. "Our efforts in market development through agronomic science will benefit by our association with these well-respected industry leaders."

Mr. Connochie currently serves as Director and Past Chairman of Canpotex Limited, and as a Director for Saskatchewan Potash Producers Association and The Fertilizer Institute (TFI). He joined PCA as Chairman in February, 1986, following the company's acquisition by Rio Algom. PCA operates two mines in Canada, an ocean terminal at St. John, NB, and markets potash on a worldwide basis. An engineering graduate of the University of British Columbia, Mr. Connochie earned the M.B.A. in 1967 from the University of Western Ontario.

R.G. Connochie

Mr. Latiolais, who is also Senior Vice President of Freeport-McMoRan, is involved with diverse operations and growth opportunities in the U.S. and Canada. He also serves on the Board of Directors of the International Fertilizer Association, PhosChem, Inroads, LSU Foundation, and the Florida Council of 100. A graduate of Louisiana State University, Mr. Latiolais participated in the Program for Management Development, Harvard Graduate School of Business Administration.

R.L. Latiolais

In other action of the PPI Board, **Mr. C. Steve Hoffman**, of IMC Fertilizer Group, Inc., was elected Finance Chairman. **Mr. Thomas J. Wright**, former Chairman of the PPI Board, was named Chairman Ex Officio.

Dr. B.C. Darst, President of FAR, also announced other actions following the recent annual FAR Board meeting. **Mr. R.H. Foell**, Marketing Manager, Post Products, of ICI Americas Inc., and **Mr. Roy J. Richard**, Group Vice President and General Manager, ConAgra Fertilizer Company, were named to the FAR Board of Directors. ■

Soil Fertility Management for Conservation Tillage

By Harold F. Reetz, Jr.

Changes in crop rotations and the shift to reduced tillage, which leaves more crop residues on the soil surface, have raised some new questions and problems relating to fertility management.

FARMERS are conserving soil resources and reducing the potential for erosion contaminating surface water. Improved field equipment, better pest control options, and innovative management systems have helped make this possible.

Compliance with government program mandates and regulations will force further adoption of conservation practices in the next few years.

Build Fertility First

Farmers should consider taking care of buildup fertilizer needs before switching to reduced tillage systems. Where serious nutrient deficiencies exist, it is important to mix nutrients with as much of the root zone as possible. Deeper tillage provides best mixing. Moldboard plowing usually mixes deeper and more thoroughly than chisel systems. Chisel plows and field cultivators mix fertilizer materials about half the depth of the tillage. This will vary with different types of tillage implements.

If fertility is high, timing and placement of fertilizer are less critical. More options are available for supplying maintenance fertilizer. A Minnesota study, evaluating placement systems for ridge planted and chisel plow systems on corn, demonstrated the value of building soil test levels before changing tillage systems (**Table 1**). With high fertility, yields were higher in both systems, and with all placement options. There was little difference among the placement options. With low fertility, placement of the fertilizer in a subsurface band was beneficial, although yields were still lower than the high fertility treatments.

The cost of buildup fertilizer should be considered a capital investment to be amortized over a period of 5 years or more. In most cases, the buildup from a medium to a high soil test level will increase yields enough that the buildup cost will be recovered in the first 2 to 3 years. The benefits continue to accrue as long as the soil test is maintained at the higher level. So the cost of NOT building soil tests, as measured in lost opportunity for higher yields and profits, should also be considered in evaluating the economics of building soil fertility.

Stratification of Nutrients

Under reduced tillage, nutrients tend to concentrate within 3 to 4 inches of the soil's surface, particularly potassium (K)

Table 1. Corn yields as affected by fertilizer placement, soil fertility, and tillage method.

	Low Fertility		High Fertility	
Placement	**Ridge**	**Chisel**	**Ridge**	**Chisel**
No P or K	79	77	152	145
Broadcast	98	109	156	151
Surface Band	109	103	150	153
Subsurface Band	115	116	154	154

44 lb/A P_2O_5 and 87 lb/A K_2O. Minnesota
Subsurface bands placed 6 and 8 inches deep.

Dr. Reetz is Midwest Director of the Potash & Phosphate Institute (PPI), Monticello, IL.

CONDITIONS associated with conservation tillage systems can affect nutrient availability to plants.

and phosphorus (P) which are relatively immobile. Both P and K applied to the surface move down very slowly, and over time accumulate in the top part of the root zone. Nutrients taken up by the plant from deeper in the root zone are also left on the surface in crop residues. As those residues decompose, the nutrients are released at the surface and move only slowly into the soil.

Since there is little downward movement, there is not much opportunity to replenish the nutrients removed in the lower part of the root zone. The nutrient content of that area decreases, while the accumulations near the surface result in increased nutrient content of the upper part of the root zone. See **Figure 1**.

The net effect is a stratification, or layering, of nutrients in the soil. The amount of stratification for each nutrient will depend upon on how much each individual nutrient actually moves in the soil. Because P and K move very little in most soils, they will be more likely to concentrate near the surface and become depleted lower in the root zone. Nitrogen moves readily in the soil, so it will be moved lower in the root zone as water moves downward.

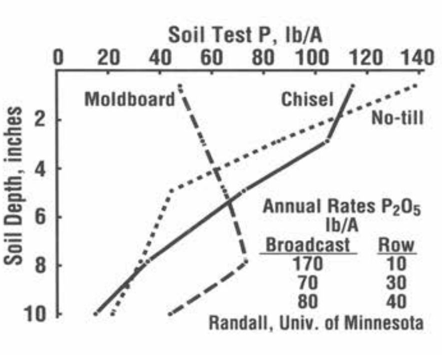

Figure 1. Tillage systems can have significant effects on soil nutrient stratification. Phosphorus was concentrated in the surface soil by reduced tillage in this study (Minnesota).

Long-term tillage studies throughout the Midwest show this stratification to be common on many soils. However, it is usually not a major deterrent to reduced tillage because the roots are often more concentrated near the surface in reduced tillage systems, and therefore better able to utilize the shallow supplies of nutrients.

(continued on next page)

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Since water is also more likely to be available near the surface in reduced tillage systems in humid areas, another factor for efficient use of shallow nutrients is in place. On the other hand, nutrient stratification in reduced tillage systems may be more important and yield-limiting under restricted rainfall conditions in the western Corn Belt and Great Plains.

As a result of greater water availability near the soil surface, reduced tillage systems in the Midwest do not usually suffer yield loss from the stratification of nutrients. A study at Purdue University that has been in place for nearly 20 years shows that comparable yields can be obtained under a variety of tillage systems—moldboard, chisel, no-till—if plant populations and pest management are adequate.

Starter May Be More Beneficial

In reduced tillage systems, there is usually a greater chance for a response to starter fertilizer. Extra residue left on the surface helps hold soil in place and increases infiltration of water, but it also reflects sunlight and reduces evaporation, so the soil tends to be cool and wet longer into the growing season. Such conditions increase the response to starter fertilizer.

Twenty years ago, researchers and Extension specialists were telling farmers they did not need starter fertilizer, especially on dark-colored soils, if P and K soil tests were in the high range. Under those conditions, that was sound advice. But conditions have changed as farmers have adopted conservation tillage practices. Even the dark-colored soils dry out and warm up more slowly when crop residues are left on the surface. The root system develops more slowly under cool, wet conditions, so nutrients and water must be supplied by a limited number of roots.

"Farmers should consider taking care of buildup fertilizer needs before switching to reduced tillage systems."

Starter fertilizer provides a concentrated supply of nutrients that helps meet the crop needs until the root system can develop. Starter fertilizer is now more likely to produce a yield response than it was 20 years ago, because the root environment has been changed through conservation tillage.

Recent research from the University of Wisconsin, reported in another article in this issue, shows that the benefits of starter fertilizer may actually be greater for late-May planted corn than for late-April planting dates, especially for no-till systems.

Research at a number of universities and locations has shown a greater starter response with no-till or reduced tillage systems compared to systems with a large amount of tillage (**Table 2**).

Reduced tillage systems tend to produce lower soil temperatures which enhance responses to starter.

Teamwork in Conservation Plans

As farmers work toward meeting conservation compliance mandates and regulations, they should develop a team approach. The farmer, any landowners involved in the operation, the local Soil Conservation Service (SCS), Cooperative Extension agents, and the fertilizer dealer should all be involved in the planning wherever possible. When these people work as a team to develop the plan, their expertise and experience can be drawn upon to make sure the plan includes the best management practices for the individual fields involved.

The farmer and landowners ultimately must make the decisions as to which

Table 2. Starter responses are frequently greater in no-till or reduced tillage systems.

	Response to Starter, bu/A		
Tillage System	Alabama Grain sorghum	Alabama Corn	Wisconsin Corn
Conventional	7	20	9
No-till	16	47	20
Soil test P	High	High	Medium

"Changing tillage changes the environment in which roots will grow and in which soil nutrient reactions take place."

practices will be adopted. The fertilizer dealer probably has the most detailed input into the final plan. The role of SCS and Extension staff is to provide technical assistance, but they cannot possibly provide detailed site-specific management plans for each farm in their area. Reduction in force of both SCS and Extension will make this type of involvement even more difficult in the coming years.

Agronomic consultants will play a greater role in farming decisions in the future. These may be consultants working in conjunction with the fertilizer dealer, or they may be independent consultants. In either case, the consultant can provide assistance with soil testing and interpretation, with pest management decisions, and a variety of other technical inputs. A local consultant can offer more individualized assistance than the SCS or Extension staff, because the consultant will have a smaller number of clients. The farmer's own experience and expertise will help determine the role for the consultants he hires.

Summary

Planning fertility management for conservation tillage requires a systematic approach. Changing tillage changes the environment in which roots will grow and in which soil nutrient reactions take place.

A team of local support people should be involved in working out the details of a conservation/fertility management plan, taking advantage of the expertise and experience available to develop a program that is agronomically sound, economically efficient, and environmentally beneficial. ■

"Roots of Plant Nutrition" Conference Set for July 8-10, 1992

THE Potash & Phosphate Institute (PPI) and the Foundation for Agronomic Research (FAR) will host a research conference, "Roots of Plant Nutrition," July 8-10, 1992 at the Chancellor Hotel and Convention Center in Champaign, IL.

The conference will address the physical, biological, chemical, and environmental considerations relating to root growth and plant nutrition. It will be a unique opportunity for basic researchers to share their work with those who apply the technology in the field. Ample time is allowed for open discussion of what is known about the crop rhizosphere and the questions that remain to be answered.

Invited papers will be presented by leading researchers in these subject areas. Volunteer poster papers from other researchers and graduate students will be accepted for either indoor displays and presentations or field demonstrations. Commercial displays will feature latest technology in equipment for root research, soil sampling, soil and plant analysis, field monitoring, and other related work. A published proceedings will be available at the conference.

The conference is oriented toward university (teaching, research, extension) and industry agronomists, crop consultants, SCS and Extension Service field staff, and others interested in the application of agronomic technology to the field. Research presentations will emphasize the practical application of the latest knowledge of crop root systems and their environment. Graduate students are encouraged to present poster papers on their research in progress on topics related to roots and plant nutrition.

Registration materials can be obtained from the Potash & Phosphate Institute (PPI), 2805 Claflin Road, Suite 200, Manhattan, KS 66502, (913) 776-0273. For further information, contact Dr. Harold Reetz, Potash & Phosphate Institute (PPI), R.R. #2, Box 13, Monticello, IL 61856, phone/FAX (217) 762-2074 or the PPI Manhattan, KS office. ■

Level of Water-Insoluble Phosphorus Is Not Affecting the Performance of Superphosphate Fertilizers

By G.L. Mullins and C.E. Evans

The quality of phosphate rock (PR) used to manufacture fertilizer for North American farmers is slowly declining. Lower grade PR can result in the formation of impurity compounds, primarily iron (Fe) and aluminum (Al) phosphates, in the final phosphate fertilizer products. Identified impurity compounds have been shown to be insoluble in water and vary in citrate solubility. Thus, the use of lower grade PR can result in a decrease in the percentage of water-soluble phosphorus (P) in a fertilizer. There is some concern that increasing levels of water-insoluble P may be detrimental to fertilizer effectiveness. Results from this study do not support that concern.

GREENHOUSE and field tests were conducted to evaluate the performance of commercial superphosphate fertilizers as affected by the level of water-soluble P and metallic impurities. Samples of six commercial triple superphosphates (TSP) and one commercial normal superphosphate (NSP) were collected for study. Three of the fertilizers were produced from Florida PR, one from North Carolina PR, one from Idaho PR and two from Moroccan PR. The U.S. sources were representative of commercial TSP currently available to farmers in the U.S. and Canada.

In a greenhouse test, these fertilizers were compared to reagent-grade monocalcium phosphate (MCP), approximately 100 percent water-soluble. Monocalcium phosphate is considered to be the primary form of water-soluble P in commercial TSP. Water-soluble P in the phosphate fertilizers ranged from 80 to 97 percent (**Table 1**). The concentrations of Al and Fe (metallic impurities) in the U.S. fertilizers averaged four to six times higher, compared to the Moroccan TSP.

Greenhouse Study

A greenhouse study evaluated each source applied to a 3.3 lb pot of Mountview silt loam soil (pH = 6.5) at rates to supply 0 to 50 parts per million (ppm) P. Sorghum-sudangrass was used as a test crop and was harvested 28 and 56 days after planting. Forage yields (**Figure 1**) and P uptake by the plants were

Table 1. Chemical composition of TSP fertilizers used in field and greenhouse studies.

Source Number	PR Source	Total P	Citrate Insoluble P	Water-Soluble[1] P	Al	Fe
		percent				
1	Florida (FL)	19.2	0.59	80	0.92	1.43
2	Florida (FL)	20.8	0.78	86	0.75	1.43
3	Florida (FL)	20.7	0.99	83	0.99	1.47
4	North Carolina (NC)	20.7	0.78	87	0.28	1.13
5	Morocco (MR)	21.2	0.75	92	0.19	0.20
6	Morocco NSP	7.9	0.20	93	0.20	0.11
7	Idaho ID	19.7	0.02	92	0.82	0.60
8	Reagent grade MCP	26.1	0.01	97	<0.01	<0.01

[1]Percentage of available P that is soluble in water. "Available" P = water + citrate soluble P.

G.L. Mullins is Associate Professor and C.E. Evans is Professor, both in the Department of Agronomy and Soils and Alabama Agricultural Experiment Station, Auburn University, AL 36849-5412. Alabama Agric. Exp. Stn. Journal Series No. 3-912932P.

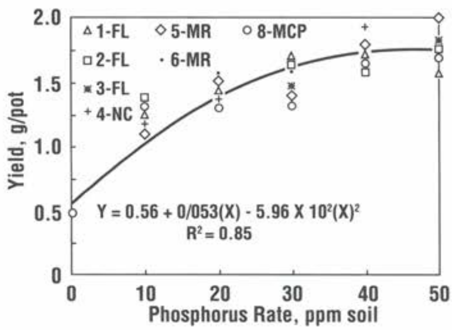

Figure 1. Yield of sorghum-sudangrass 56 days after planting as affected by the rate and source of superphosphate.
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increased by increasing rates of added P. However, forage yields and P uptake were not affected by the P source. Results indicated that the commercial fertilizers tested were as effective as reagent grade MCP and that fertilizer performance was not related to the level of water-soluble P or the level of metallic impurities (Al and Fe).

Field Study

A field study was also conducted using TSP sources manufactured from RP sources 1, 3, 4 and 5 (**Table 1**). The three-year test was conducted on a Hartsells and a Malbis soil. White potato was used as the test crop because of its high P requirement and its consideration as a crop that may require a high percentage of water-soluble P. The TSP was band-applied on each side of the potato seed pieces at planting.

Potato yields were consistently increased by added P (**Figure 2**). During the three-year study, potato yields were increased by as much as 163 cwt/A by the application of P. Yields were not affected by the source of added P or the level of water-soluble P in the fertilizers during the three-year study. The concentration of P in the potato leaf tissue likewise was not affected by the source of applied P.

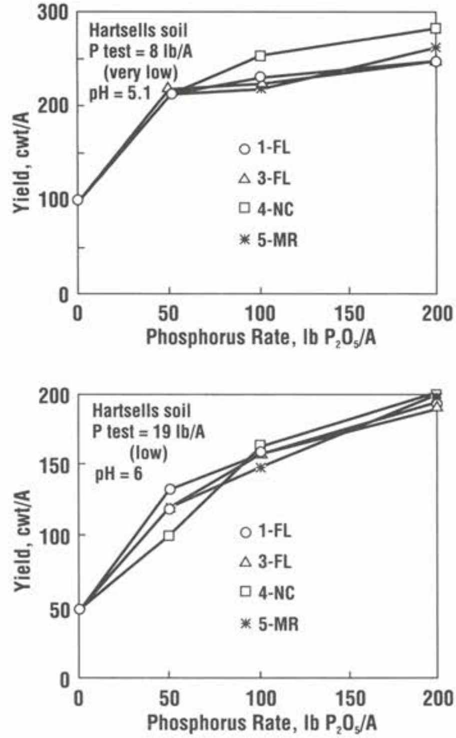

Figure 2. Potato yields on a Hartsells and a Malbis soil in 1989 as affected by the rate and source of commercial triple superphosphate.
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Summary

Results of these studies show that commercial TSP fertilizers vary in their content of water soluble P and metallic elements. However, greenhouse and field evaluations of commercial sources of TSP showed that fertilizer performance was not related to the level of water-soluble P or the content of metallic impurities. The results demonstrate that current levels of water-insoluble P (impurity compounds) in TSP produced from North American rock phosphate sources are not an agronomic problem. ■

Some Facts on
Phosphate

Phosphate rock is a naturally-occurring material used in almost all phosphate (P) fertilizer production. The most important rock deposits are sedimentary materials, laid down in beds under the ocean and later lifted up into land masses.

KNOWN world reserves of phosphate rock approach 100 billion tons. About half this can be economically recovered under today's conditions. This tonnage represents enough phosphate to meet present consumption rates for hundreds of years. As the economics change, even greater amounts can be recovered.

U.S. deposits (phosphorite) are found in Florida, North Carolina, Tennessee, Idaho, Montana, Utah and Wyoming. They represent about 30 percent of the world's known reserves. More than three fourths of the U.S. production comes from Florida and North Carolina, with the remainder coming from the western states and Tennessee.

Almost all phosphate rock is mined by strip mining. It usually contains about 15 percent P_2O_5 and must be upgraded to be used for fertilizer. Upgrading, in a process called *beneficiation*, removes much of the clay and other impurities, and raises the P_2O_5 content to 30 to 35 percent.

Following beneficiation, the rock phosphate is finely ground. Although it can be applied directly as rock phosphate fertilizer, the P in it is slowly released and seldom benefits crops during the first two or three years after application. *Most of the rock phosphate is treated to make the P more soluble.*

Fertilizer phosphates are classified as either **acid-treated** or **thermal-processed**. Acid-treated P is by far the most prevalent. Sulphuric and phosphoric acids are commonly used in producing acid-treated phosphate fertilizers.

Sulphuric acid is produced from elemental sulphur (S) or from sulphur dioxide. More than 60 percent of industrial sulphuric acid is used to produce fertilizers. Treating rock phosphate with concentrated sulphuric acid produces a mixture of *phosphoric acid* and *gypsum*. Filtration removes the gypsum, leaving "green" or "wet-process" phosphoric acid containing about 54 percent P_2O_5.

Wet-process acid can be further concentrated to form **superphosphoric acid**. In this process, water is driven off and molecules with two or more P atoms are formed. Such molecules are called **polyphosphates**.

Acid-Treated Phosphate Fertilizer Materials

Normal superphosphate (20 percent P_2O_5) is made by treating rock phosphate with a measured amount of lower concentration sulphuric acid.

Concentrated superphosphate (triple superphosphate; 46 percent P_2O_5) comes from reacting wet-process phosphoric acid with rock phosphate.

Ammonium phosphates are produced by ammoniating phosphoric acid. Monoammonium phosphate (MAP) contains 10 to 12 percent N and 48 to 55 percent P_2O_5; diammonium phosphate (DAP) contains

This article was prepared by agronomists of the Potash & Phosphate Institute (PPI). For more information, contact Dr. Harold F. Reetz, Jr., PPI Midwest Director, R.R. 2, Box 13, Monticello, IL 61856; phone (217) 762-2074.

18 percent N and 46 percent P_2O_5 (18-46-0). The difference is determined by controlling the amount of added ammonia.

Ammonium polyphosphates are usually fluid sources of P produced by ammoniating superphosphoric acid. Polyphosphate content ranges from 40 to 70 percent. Analysis of polyphosphate liquid fertilizers ranges from 10-34-0 to 11-37-0.

Nitrophosphates are made by reacting rock phosphate with nitric acid. Some sulphuric or phosphoric acid may be used along with the nitric acid to make the material more water soluble. Most nitrophosphates are used in Europe.

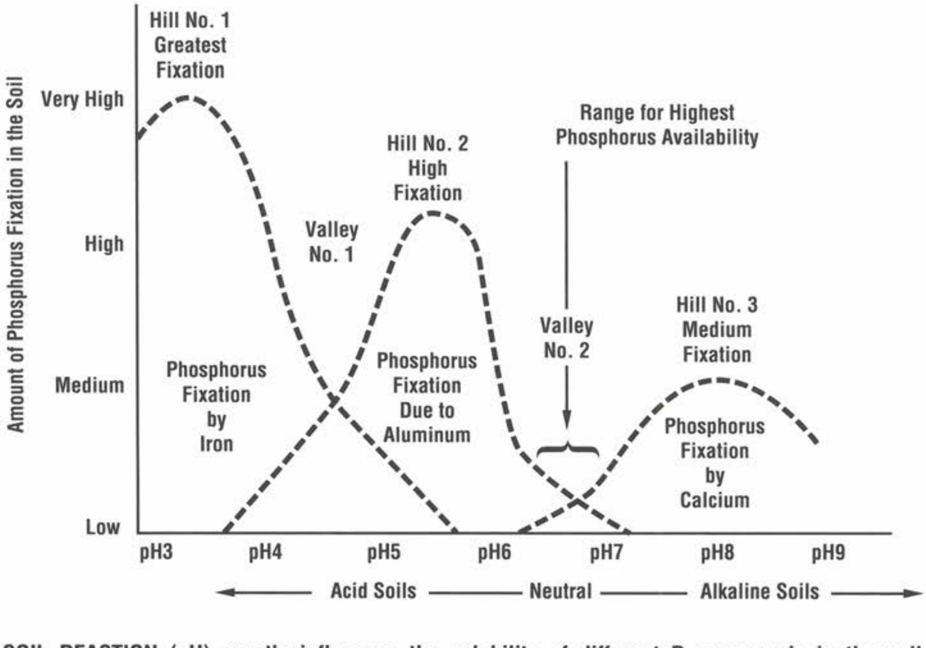
Ammoniated superphosphates are made by reacting normal or triple superphosphate with ammonia. They are available in different fertilizer grades and water solubilities. The water soluble P content is variable, influenced by *phosphate source, degree of ammoniation, content of impurities, moisture content, speed of drying, etc.*

Thermal Phosphoric Acid

Thermal phosphoric acid is produced by first producing elemental P through the reduction of phosphate rock with coke in an electric arc furnace. Elemental phosphorus is oxidized to P_2O_5 which is subsequently reacted with water to form **furnace grade phosphoric acid** (H_3PO_4).

Thermal acid is much purer than wet-process H_3PO_4. Its use in fertilizer manufacture is sometimes preferred for the production of liquid fertilizers because of its purity. *Agronomically, products derived from furnace grade phosphoric acid and those produced from merchant grade phosphoric acid are identical.* ■

The Hills and Valleys of Phosphorus Fixation



SOIL REACTION (pH) greatly influences the solubility of different P compounds in the soil. Solubility indicates how available the P is, or how fixed or "tied up" it becomes in the soil. The more soluble or available forms exist in the 5.5 to 7.0 range. This makes a sound liming program essential on very acid soils. Lowering the pH of alkaline soils to improve availability is not very practical.

Texas Research

Best Management Practices for Southern Dairy Forages

By J. Neal Pratt, Johnny Cates, David McGregor, and Larry Sanders

Warm season perennial forages can provide high yields . . . and high quality . . . with adequate fertilization and good forage management. Dairy producers can quickly benefit from improved forage quality.

WARM SEASON PERENNIAL GRASSES are noted for their low quality. Yields and quality of warm season perennials, however, can approach that of alfalfa with use of proper fertility inputs and management.

A system of best management practices (BMPs) that can maintain high quality and high yields of warm season perennial forages includes:

- a soil testing program
- a forage analysis program
- a timely and accurate fertilization schedule
- forage management techniques for maximizing leaf production.

Maximum Leaf Production Is a Key

Total mixed ration formulation for feedlot dairy cattle is much simpler than nutrient management of dairy cattle on pasture. Since pastures are growing plants, they are subject to continual change. Forage changes directly affecting animal performance can, however, be compensated for with BMPs to positively influence dairy production.

The milking herd needs high quality forage. Quality of warm season perennial grasses such as Coastal bermudagrass declines rapidly as the leaf-to-stem ratio decreases (**Figure 1**). As the plant grows, the leaf-to-stem ratio decreases, with a corresponding decline in protein and other quality factors. Cattle performance is highest when the proportion of leaves is 85 percent and greater.

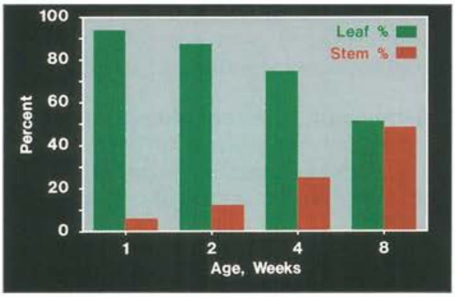


Figure 1. Leaf percent declines as stem increases with age of Coastal bermudagrass.
Source: Burton and Prine.

Figure 2 shows a simplified diagram of the differences between a leaf cell and a stem cell and their relative differences in digestibility. This difference in digestibility produced by increased plant maturity and a lower leaf-to-stem ratio significantly affects animal performance. A 1 percent increase in digestibility can produce as much as a 5 percent increase in milk production.

Pastures can be maintained in a lush, vegetative state by heavy grazing pressure and/or frequent mowings. This pressure keeps the grass short, breaking apical dominance and promoting growth of lateral buds and leaves. This produces a leafy, high quality forage with high digestibility.

Dr. Pratt is with the Texas Agricultural Extension Service, College Station, TX. Mr. Cates is Wood County Extension Agent, Quitman, TX. Mr. McGregor is Waller County Extension Agent, Hempstead, TX. Dr. Sanders is Great Plains and Southwest Director, Potash & Phosphate Institute (PPI), P.O. Box 23529, Stanley, KS 66223.

IMPROVED management of Coastal bermudagrass and other forages can be profitable for dairy producers.

Properly managed pastures have more the appearance of a lawn than a conventional pasture. The practice of keeping stem length to a minimum creates a higher leaf-to-stem ratio.

Digestibility of bermudagrass leaf materials may be 65 percent or more, but once rapid stem growth begins, digestibility drops quickly. As the stem portion increases, digestibility may decrease to 50 percent or less. Cattle consume less of the stemmy, mature forage because the cell wall portion is less digestible and it stays in the rumen longer. This causes a serious decline in milk production.

Dairy Producers Demonstrate BMP Approach

A dairy forage management plan was designed by Texas A&M personnel based on previous regional research. Results of a long-term field trial established on the Clifford and Randall Davis Dairy in Wood County, TX, demonstrated the advantages of applying modest amounts of nitrogen (N) at 31-day intervals throughout the growing season and removing ungrazed forage when growth exceeded 3 inches in height. Records indicated that milk production began to decline 3 days prior to, and increased 3 days following the 31-day fertilizer application interval. A modified schedule was later developed for applying N,

"Properly managed pastures should have more the appearance of a lawn than a conventional pasture."

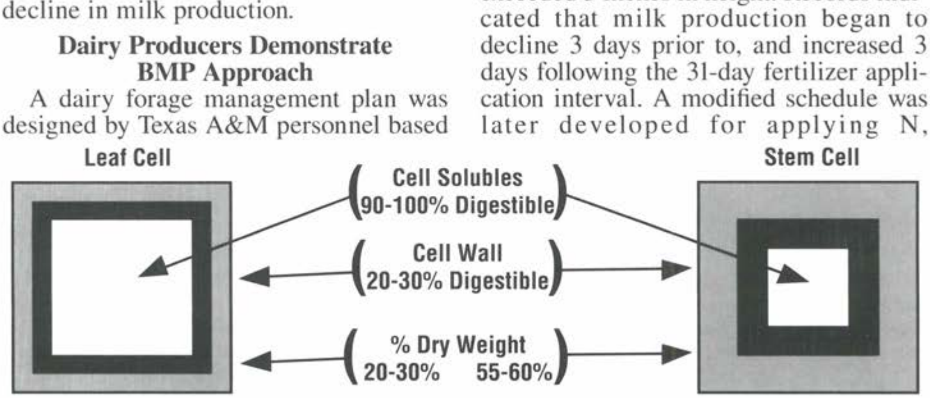


Figure 2. Relative differences in leaf and stem cells. Leaf cells contain more cell solubles, which are highly digestible. Source: McNeill

Table 1. Date, rate, and analysis of fertilizer application based on soil and plant analyses, Waller County, TX.

Date	Fertilizer Applied, lb/A	Fertilizer Analysis, % N-	P_2O_5-	K_2O-	S-	Mg-	Zn
May 2	200	0	0	60			
May 2	200	18	46	0			
May 2	200	0	0	22	22	11	
May 19	300	21	7	14	6	1	
June 8	300	21	7	14	6	1	
July 9	300	14	7	21	7	2	1.6
July 30	314	14	7	21	7	2	1.6
Aug 20	300	14	7	21	7	2	1.6
Sept 9	300	14	7	21	7	2	1.6
Sept 30	300	14	7	21	7	2	1.6
Total	2,714						

phosphorus (P) and potassium (K) every 24 to 26 days.

Results indicated that milk production equaled production from sorghum-sudangrass or millet forages during June through August and increased 5 to 8 lb per cow during September and October. Pasture costs per cow decreased from $0.25 to $0.11 per day. No hay was fed to the lactating herd until October. Other area demonstrations have also shown an average of 5 lb per cow per day increase over previous forage systems used.

Based on the success at the Davis Dairy, a similar project was initiated on the Silverwood Dairy in Waller County. Fertilizer was applied every 21 days and half of the Coastal bermudagrass pasture was shredded every 7 days. Initial fertilizer nutrient rates were based on soil tests. Forage samples were collected and analyzed every 7 days. As the season progressed, plant analyses showed that forage K was less than 2 percent, which is below optimum for this production system.

One of the important roles of K in animals is reduction of heat stress in lactating cows when humidity is high and the temperature exceeds 85°F.

Fertilizer practices were then modified to include higher rates of K (**Table 1**). Forage K levels improved for several sampling dates. As drought conditions continued during the summer, K levels fluctuated with climatic conditions and root activity.

"The BMPs outlined here are agronomically, economically, and environmentally responsible management techniques that dairy-men can incorporate into their ongoing dairy enterprises."

Forage protein and energy levels and milk production showed substantial increases over previous years with use of these BMPs. Based on plant analyses, soybean meal content in concentrate rations was reduced from 800 to 200 lb/ton of mixed feed, and milk production was maintained through the summer drought.

BMP Forage Roadmap for Southern Dairies

Several dairies in eastern Texas have initiated forage management programs which include the following BMPs:

A. Soil Testing Program. The soil test is the starting point for design of a basic fertility plan. Soil tests should be used to monitor and maintain adequate soil fertility.

B. Forage Analysis Program. Forage samples should be collected and analyzed weekly by a laboratory. The results can be used to monitor protein and other nutritional factors so that in-season adjustments in fertilizer and forage management can be made to keep dairy cows operating at peak performance.

Currently, dairy producers are applying 50 to 60 lb N/A plus other nutrients shown to be deficient at 21 day intervals.

C. Timely and Accurate Fertilization Schedule. Fertilization plays an important role for sustained plant growth and drought tolerance, helping insure the success of intensively managed warm season perennial dairy pastures in the South. The following guidelines should be helpful:

1. Provide adequate nutrition to meet the needs of the forage being grown. Warm

season perennial grasses are big nutrient users.

2. Balance N with P, K, S, Mg, and other nutrients to optimize yield and quality and to maintain high nutrient use efficiency.

3. Apply secondary and micronutrients as needed, using soil testing and plant analyses.

4. Apply nutrients at short, uniform intervals (21 to 24 days) to keep management simple and to stabilize milk production.

5. Keep soil pH in the range best suited for optimum forage production (pH 6.0 to 7.0).

D. Forage Management for Maximum Leaf Production. Managing for maximum leaf production is the objective of this system. Power fencing with small grazing cells where cattle are mob-grazed and rotated on short intervals will work best. With larger pastures, mowing each half of the pasture on a 7 to 10 day interval will keep the pasture at a 3 inch height or less.

This system may require 5 to 7 cows per acre stocking rate to maintain the grass at minimum heights. If "manure spots" develop, they should be mowed along with a drag attachment to help scatter existing manure. Frequent removal of stemmy and excess forage will provide a constant source of high percentage leaf material with minimal stem.

Advantage of BMPs

The BMPs outlined here are agronomically, economically, and environmentally responsible management techniques that dairymen can integrate into their ongoing dairy enterprises. In this case, BMPs serve the farmer, the fertilizer dealer, and the environment.

The dairyman not only benefits from yield, quality, and economics of forage and milk production with BMPs, but labor is utilized more efficiently as well. The fertilizer dealer benefits by having his work load spread over a longer season. The environment is protected by split applications of fertilizer, and enhanced nutrient use efficiency. ■

Louisiana

Effect of Sulphur Fertilization on Yield, Copper Concentration and Copper Uptake in Coastal Bermudagrass

RESEARCH at the Louisiana Hill Farm Research Station has reported forage yield responses to sulphur (S) applied to Coastal bermudagrass at two locations over a 5-year period. Yield increases have been measured from S applications up to 96 lb S/A. Sulphur fertilization reduced copper (Cu) concentrations from 5 to 4 parts per million (ppm), but Cu uptake was not significantly affected at either site.

The table shows some effects of S fertilization. ■

Effects of S fertilization on Coastal bermudagrass yields, Cu and S concentrations and uptake.

	S		Cu		
Applied S	Conc.	Uptake	Conc.	Uptake	Yield
lb/A	%	lb/A	ppm	lb/A	lb/A
0	.13	16	5	.06	12,590
24	.16	22	4	.06	13,091
48	.20	28	4	.06	13,505
72	.24	34	4	.06	13,862
96	.28	42	4	.06	14,582

Mahan fine sandy loam;
Soil test (0-15 cm): S, 8 ppm; Cu, 0.2 ppm.

Source: Dr. Marcus Eichorn, Hill Farm Research Station, Louisiana State University.

Kansas Research

Phosphorous Boosts Long-Term Corn and Sorghum Yields, Reduces Soil Nitrate Carryover

By Alan Schlegel and Kevin Dhuyvetter

A 30-year irrigated corn and grain sorghum study in western Kansas continues to emphasize the importance of phosphorus (P) for irrigated crop production. Phosphorus use has increased yield, increased crop response to nitrogen (N), and diminished nitrate-N accumulation in the soil.

FOR THE PAST 30 YEARS, a study at the Tribune Unit of the Southwest Kansas Research and Extension Center has demonstrated the importance of good fertilization practices in production of continuous irrigated corn and grain sorghum. The corn and grain sorghum plot areas in this study are adjacent (located on a Ulysses silt loam soil) and receive furrow irrigation. Fertilizer treatments include N rates ranging from 0 to 200 lb N/A in 40 lb increments, with and without P at a rate of 40 lb P_2O_5/A.

Over the years, crop responses to added P have continued to increase as soil test P levels have been drawn down by lack of P application. Corn has shown the largest responses to P because of higher average yields.

Phosphorus Differences Increase

Over the years, data from this study have indicated that maximum corn yields were achieved with N application rate of about 160 lb/A. At that optimum N rate, application of P has continued to increase its effect on corn yields (**Figure 1**). With N application rate of 160 lb/A, P produced an average yield increase of 38 bu/A from 1961 to 1991. From 1982 to 1991, P increased yields an average of 57 bu/A and in 1991 P increased yields 117 bu/A for a top yield of 206 bu/A.

Grain sorghum yields in this study have always been lower than corn. Similarly, P effects on yields have also been smaller but still highly significant (**Figure 1**). With N rate of 120 lb/A, 31 years of data indicated an average P yield increase of 15 bu/A. From 1982 to 1991, that effect increased to 24 bu/A and in 1991 P increased sorghum yields 38 bu/A.

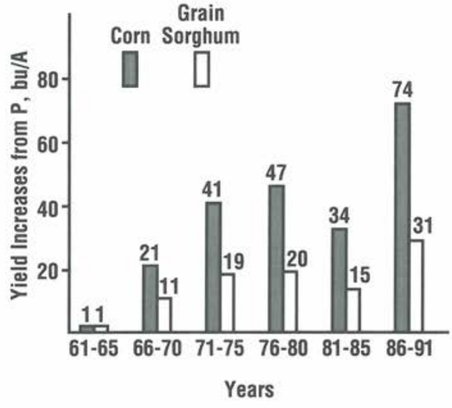


Figure 1. Irrigated corn and grain sorghum yield increases from fertilizer P have increased with time.

Nitrogen and Phosphorus Removal in Soil Test Levels

Amounts of N and P removed in the grain have increased with increasing N and P applications for both corn and grain sorghum. Grain N and P removal was about 50 percent higher for corn than

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grain sorghum, reflecting the higher corn yields. At an optimum N rate of 160 lb/A without added P, corn grain removed about 67 lb N/A in 1990 compared to 104 lb N/A at the same N rate when P was supplied. With N rate of 120 lb N/A, grain sorghum without added P removed only 57 lb N/A; that amount increased to 77 lb N/A with 40 lb P_2O_5.

The effects of proper rates of N application with added P on nitrate accumulation in the soil over a 30-year period are indicated in **Figure 2**. Soil was sampled to a depth of 10 feet and showed a net accumulation of 224 lb nitrate-N/A at a rate of 160 lb N without added P. When P was supplied, the accumulated amount of nitrate-N was only 48 lb/A, emphasizing the improved N use efficiency from P fertilization.

Grain sorghum production resulted in similar soil nitrate-N accumulations with similar P effects. At a rate of 120 lb N/A without P, the 30-year accumulation of nitrate-N to a depth of 10 feet was 193 lb/A; it dropped to only 52 lbs when P was supplied at the same N rate. However,

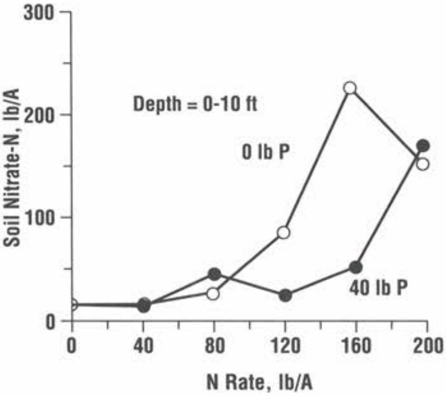

Figure 2. Nitrogen rate and P application effects on nitrate-N accumulation in the soil (corn, Kansas research).

when N was increased to 160 lb/A without P, residual nitrate-N jumped to 750 lb/A; it was only 195 lb/A when P was supplied. Those numbers emphasize the importance of N rate and P application for N use efficiency.

These same plots were sampled in 1973 and a comparison of the data from that

(continued on next page)

PHOSPHORUS . . . from page 17

date versus the 1990 sampling provides an interesting comparison (**Figure 3**). Phosphorus had the same dramatic effect on controlling nitrate-N accumulation and soil nitrate-N levels in the plots receiving 160 lb N plus 40 P_2O_5 actually declined slightly over that 17-year period. Without P, soil nitrate-N accumulations rose about 60 lb/A, which represents only about a 4 lb/A accumulation per year.

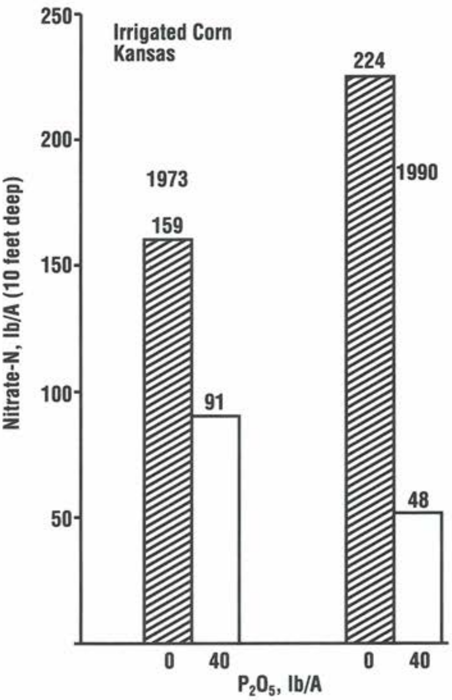

Figure 3. Soil nitrate accumulation to a depth of 10 feet has been dramatically controlled by the use of P fertilizer.

Phosphorus removal and soil test levels make an interesting comparison. In 1990, 160 lb of N without P and a yield of 118 bu of corn per acre removed about 22 lb P_2O_5/A. That constant removal over a 30-year period has caused soil test values to drop significantly from the original level (**Figure 4**). The optimum N rate of 160 lb N/A plus 40 lb P_2O_5 produced a yield of 212 bu/A in 1990 and removed about 51 lb P_2O_5/A in the grain. With an average application of 40 lb P_2O_5/A, P soil tests have been maintained at about an even level (**Figure 4**), slightly lower than the initial soil levels. This might indicate that a slightly higher rate of P application might have been beneficial for crop production even though an additional 40 lb of P_2O_5 early in the study showed no additional yield benefit.

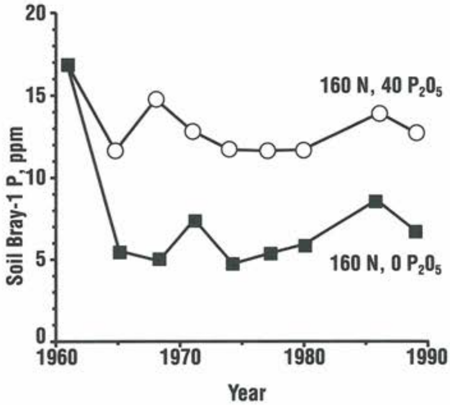

Figure 4. Corn production without application of P resulted in a decline in available soil P and yield losses.

Economic Analysis

This study provides some classic data that tie system profits with environmental protection. The data in **Figure 5** demonstrate clearly that net returns benefited from utilizing the optimum N rate with P.

Note that as yields increased, production costs per bushel dropped and net return (net revenue) increased to a maximum at about 160 lb N/A. To calculate these values, the price of corn was figured at $2.50/bu, N at $0.15/lb and other production costs at $200/A.

Analysis of the sorghum production system yielded essentially the same trends. The optimum N rate for sorghum was about 140 lb N/A with added P for medium and high yielding years and about 120 lb N/A for low yielding years. Applying N in excess of these values resulted in reduced net return and greater soil accumulation of nitrate-N.

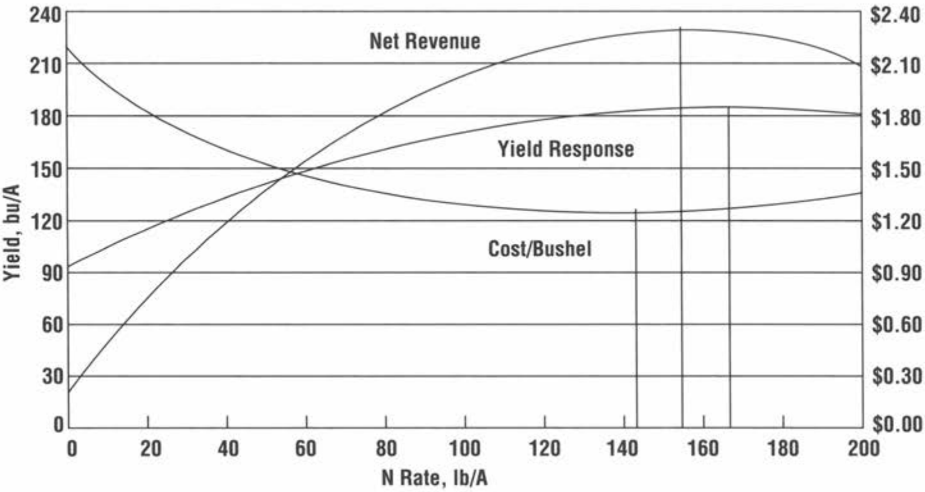

Figure 5. Yields increase, production costs per bushel decline and net returns (net revenue) increase when a production system includes adequate plant nutrients (irrigated corn, Kansas research).

Summary

This study demonstrates the benefits of long-term soil fertility investigations. Yields of irrigated corn in this system have been maintained and increased over the 31-year period of the study. Sorghum yields, however, have not kept pace and have slipped somewhat over the years. Clearly, use of a complete fertility program was able to maximize profit potential while minimizing soil-nitrate N accumulations and decreasing any hazards of potential nitrate leaching. ■

Utah

A Role for Potassium in the Use of Iron by Plants

STUDIES were conducted on iron (Fe) deficient tomato and soybean cultivars. Researchers found that neither species was able to respond to Fe stress in the absence of potassium (K) in growth solution.

The lack of Fe stress response resulted in reduced levels of leaf Fe and greater chlorosis in both species when K was omitted from the growth solution. Solution K was replaced with equal (equimolar) amounts of sodium (Na) and rubidium (Rb), but neither effectively substituted for K. It appears, from this research, that K is essential in evoking the Fe stress response which results in Fe uptake by the plant.

Researchers concluded that K seems to have a specific role in the plant for maximum utilization of Fe. ■

Source: V.D. Jolly, J.C. Brown, M.J. Blaylock and S.D. Camp, Brigham Young University, Provo, UT 84602. Published in Journ. of Plant Nutrition 11(6-11), 1159-1175 (1988).

Note: See *Potash Review*, Subject 4, 5th Suite, No. 5, p.1 (1989), for an abbreviated version of the above article.

Also for further reading: Jolly, V.D. and J.C. Brown, 1985. Iron stress in tomato affected by potassium and renewing nutrient solutions. *Journ. of Plant Nutrition,* 8(6), 527-541.

Wisconsin Research

Corn Response to Starter Fertilizer: Planting Date and Tillage Effects

By L.G. Bundy and P.C. Widen

Corn yields are often increased by starter fertilizer at early planting dates. Data in this study also indicate substantial yield benefits from starter use can occur at late May planting dates, particularly in no-till.

CORN YIELD RESPONSES to row-applied starter fertilizer are frequently reported in northern corn production areas.

These responses are often attributed to the role of starter fertilizer in compensating for the reduced root growth and nutrient availability in cold soils with early planting or in reduced tillage. However, observations from on-farm demonstrations and research trials suggest that the probability of yield response to starter fertilizer is reduced at the higher soil temperatures normally associated with later planting dates, and at high phosphorus (P) and potassium (K) soil test levels.

The economic implications of starter fertilizer use with various planting dates and in tillage systems have not been determined. In fact, corn yields in Wisconsin are usually increased by early planting and use of starter fertilizer, indicating that overall profitability in many production situations can be optimized by their use.

Grain moisture at harvest can also be influenced by planting date. Potential differences in drying costs should be considered in the economic evaluation of starter fertilizer use alternatives. The specific objectives of this evaluation of tillage and planting date effects on corn response to starter fertilizer treatments are listed below.

Objectives

- Determine corn yield response to row-applied starter fertilizer at a range of planting dates.
- Compare response to starter fertilizer in no-till and conventional tillage at each planting date.
- Study the effects of starter fertilizer composition on crop response by evaluating growth, yield, and nutrient uptake obtained with various combinations of nitrogen (N), P, and K.
- Determine economic returns from starter fertilizer use at various planting dates based on yield, fertilizer costs, and grain drying costs associated with various treatment combinations.

Materials and Methods

An experiment designed to evaluate planting date and tillage effects on corn response to starter fertilizer was conducted on the University of Wisconsin Research Station at Arlington from 1989 to 1991. The soil at the experimental site was a Plano silt loam. The site had been in continuous corn for at least 10 years. During this period, fertilizer P and K applications were approximately equal to crop removal.

A split-split plot design, replicated four times, was used with tillage (no-till or moldboard plow) designated as the main plot treatment. Individual plots were four rows (10 ft.) wide and 30 ft. long. In the moldboard plow tillage system, fall

Dr. Bundy is Extension Soil Scientist and Mr. Widen is Research Specialist, Department of Soil Science, University of Wisconsin-Madison. This article is adapted from a paper prepared for the Area Fertilizer and Aglime Dealer Meetings, December 2-13, 1991.

plowing was used with seedbed preparation by disking shortly before planting. Subplot treatments were four planting dates (late April, early, middle, and late May). A single hybrid, of 95-day relative maturity (Kaltenberg brand 5200), was used at all planting dates each year. Seeding rates were adjusted so that stands could be hand thinned to a uniform density of 24,000 to 26,000 plants/A after emergence in all treatments.

Sub-subplot treatments were four starter fertilizer additions applied at planting in a 2 x 2 placement (10 + 0 + 0, 10 + 25 + 0, 10 + 0 + 25 and 10 + 25 + 25 lb/A of N, P_2O_5 and K_2O, respectively). Ammonium nitrate (34-0-0), triple superphosphate (0-46-0), and potassium chloride (0-0-60) were used as nutrient sources. Prior to the first planting date, anhydrous ammonia was injected to provide 180 lb N/A in all treatments.

Before the first planting each year, soil samples were taken throughout the experimental area to determine initial soil test levels. Surface samples (0-to-6 inch depth) were analyzed for pH, organic matter, available P, and exchangeable K. Average initial soil test values were: pH, 6.4; P, 25 parts per million (ppm); and K, 98 ppm. Weekly plant height measurements were made in all plots until tasseling. A measurement of the percent total residue cover was made early in the growing season. Grain yields were determined by machine harvest of the middle two rows of each plot. A subsample of grain from each plot was retained for moisture measurements.

Results and Discussion

Plant height effects. The effects of starter fertilizer on plant height were most apparent in no-till at late May planting dates. Starter fertilizer had little effect on plant height at the other tillage-planting date combinations. These results show that starter fertilizer promotes more rapid crop growth in late no-till plantings. Plant height during July was consistently increased by starter fertilizer additions in each year. The largest response usually occurred when the starter fertilizer contained both P and K.

Grain yield effects. Starter fertilizer, planting date, and tillage treatments significantly affected grain yields (**Figure 1**). The moldboard plow tillage system grain yields were significantly higher than no-till except in 1991.

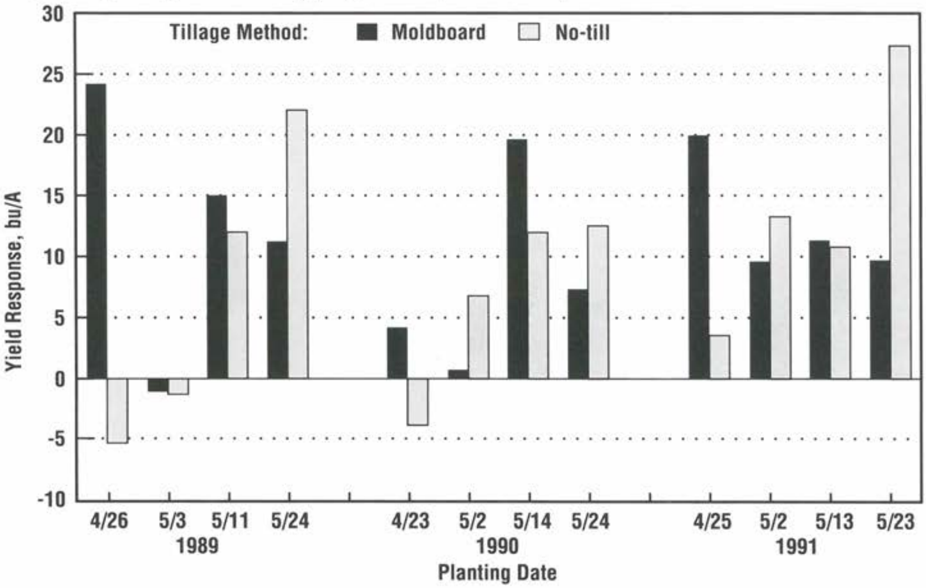

Figure 1. Starter fertilizer, planting date, and tillage treatments significantly affected corn grain yields (Wisconsin).

Planting date had a significant effect on grain yield. In most cases, early planted corn in both tillage systems produced the highest yields. Starter fertilizer treatments containing P and/or K usually increased yields relative to the control (no P or K) treatment. Starter treatments that contained P alone or both P and K usually produced the highest corn yields.

The importance of using a starter fertilizer containing both P and K is apparent from the data. Yields with this treatment were usually higher than with other starter fertilizer additions. These data suggest that, for early plantings in a moldboard plow system, using starter fertilizer that contains both P and K will produce the highest corn yields. It also suggests that yields from corn planted in late May can be significantly increased if starter fertilizer containing both P and K is used. The no-till data are similar to those in the moldboard plow system in that yields can be increased with starter fertilizer at late May planting dates, but higher yields will usually be obtained with earlier planting dates.

Grain yield responses to starter fertilizer in two tillage systems at four planting dates each year were determined by comparing yields in the control with yields where the starter fertilizer contained both P and K. Starter fertilizer increased grain yields in 20 of 24 comparisons. Positive responses to starter fertilizer ranged from 0.6 to 27 bu/A, while negative responses ranged from 1 to 5 bu/A.

Grain moisture effects. Grain moistures were significantly higher at the late-May planting dates in both tillage systems, except in 1990 where the mid-May planting date grain moistures were highest. Higher grain moistures at the later planting dates are due to the shorter growth and development period available to the crop. Starter fertilizer use usually lowered grain moisture relative to the control (no P or K) treatment. Fertilizers containing P alone or both P and K were most effective in reducing grain moisture at harvest. The effect of starter fertilizer on grain moisture is most apparent in the no-till system at the later planting dates, and is likely due to more rapid crop development where starter fertilizer was applied.

Economic analysis of starter fertilizer use. An economic analysis of starter fertilizer use at four planting dates in two tillage systems is shown in **Figure 2**. Returns

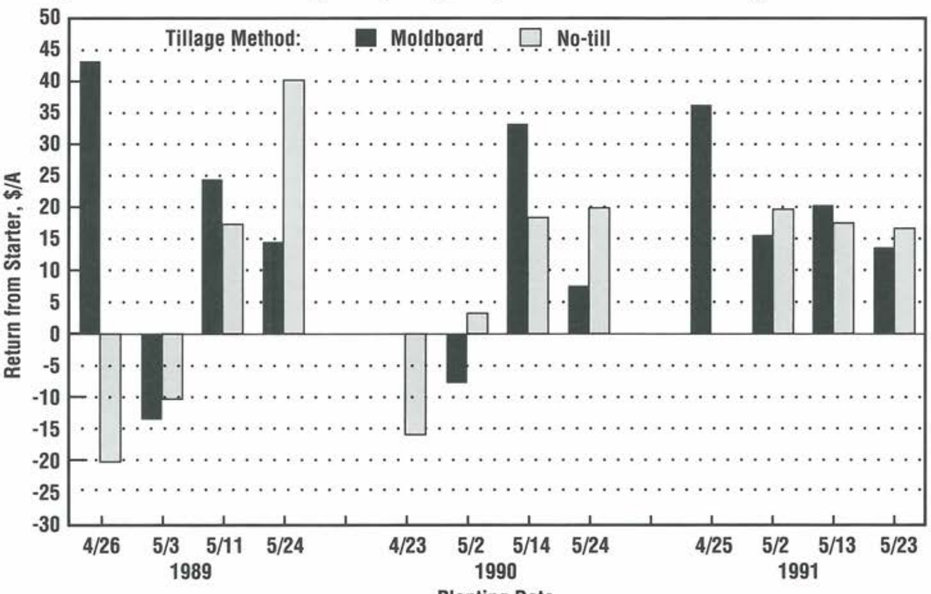

Figure 2. Economic benefits varied among planting dates and tillage systems, but starter fertilizer use was profitable in most comparisons (Wisconsin).

from starter fertilizer use were calculated using a \$2.25/bu value for corn and a \$10.00/A cost for the starter fertilizer application containing 25 lb/A of both P_2O_5 and K_2O. Grain drying costs were calculated at \$0.02/bu for each 1 percent moisture above 15 percent. For each planting date and tillage, net returns with and without starter fertilizer were compared to determine the economic benefits from starter fertilizer use. Although economic benefits varied among planting dates and tillage systems, starter fertilizer use was profitable in 19 of 24 comparisons. Economic benefits from starter fertilizer ranged from \$3 to \$43 per acre, while losses from starter fertilizer ranged from \$8 to \$20 per acre.

Summing Up

These findings indicate that starter fertilizer use is likely to be highly profitable across a range of planting dates and tillage systems. ■

Foliar Boron Fertilization of Soybeans

RESEARCHERS from five states met recently in Atlanta to discuss progress on a coordinated project dealing with boron (B) fertilization of soybeans. A common protocol has been developed to examine rates of foliar B application based on earlier studies at the University of Missouri. Participants in this multi-state project include Drs. Dale Blevins and Paul Tracy of the University of Missouri, Bob Hoeft, University of Illinois, Ed Oplinger, University of Wisconsin, Jay Johnson, Ohio State University, and Gary Gascho, University of Georgia.

Studies in 1991 indicated that a rate of 0.25 lb/A foliar B seemed to produce the most consistent yield effects. Results indicated a need to further evaluate differing responses in soybean cultivars, multiple B rates at a single, early application date, and possible examination of a band (soil application) at early trifoliate.

Support for this research is being provided by the Foundation for Agronomic Research and U.S. Borax. ■

Correction for Summer 1991 Issue

AN ERROR appears in a formula shown in **Figure 1** on page 26 of the Summer 1991 issue of *Better Crops With Plant Food,* part of an article titled "Optimum Phosphorus Management for Small Grain Production." The graph itself was correctly presented, but the formula appearing with it had a division sign (/) omitted.

The graph with the correct formula appears at right. For more information on spring wheat response to soil test phosphorus (P) level in the northern Great Plains, contact Dr. Paul Fixen, North-central Director, Potash & Phosphate Institute (PPI), P.O. Box 682, Brookings, SD 57006. ■

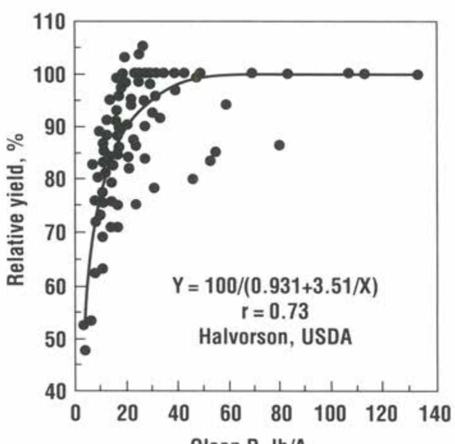

Figure 1. Spring wheat response to soil test P level in the northern Great Plains.

Which Comes First–Forms or Farms?

More and more–records and forms–long forms–in triplicate–witnessed and notarized.

Every farmer knows the problems– application forms, government program forms, tax forms, soil test forms, endless records to keep–sometimes the FORMS are more trouble than the FARMS. A frustrated farmer wrote a book entitled, "Do You Want Me To Do All That and Plow Too?" Humorous, but serious also.

An old man helps me in the yard once or twice a month. Simple enough, huh? No way! I must file and pay social security and Medicare. Also forms for unemployment insurance and workman's compensation. And a 4-page form for the state department of labor must be filed. I am now an "employer" and must describe my "business" or "establishment" in detail–whether I am in Retail Trade, Finance, Construction, etc., and my "trade name." Finally, a 7-page form dealing with illegal aliens, even though he was born in this country.

Much easier to do the yard work by myself, but the helper needs the money. Of course, he could "incorporate" but that's beyond him.

A one-day stay as an outpatient in the hospital recently called for much punching of computers by staff in five different offices, plus signing fourteen forms. One almost forgets why he came in. At least one learns patience.

On the farm, in the home, in the schools, everywhere–forms and records. Such a waste of time, talent and money. Where will it all end? No wonder farm operations, government programs, and hospital visits cost so much.

J. Fielding Reed

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