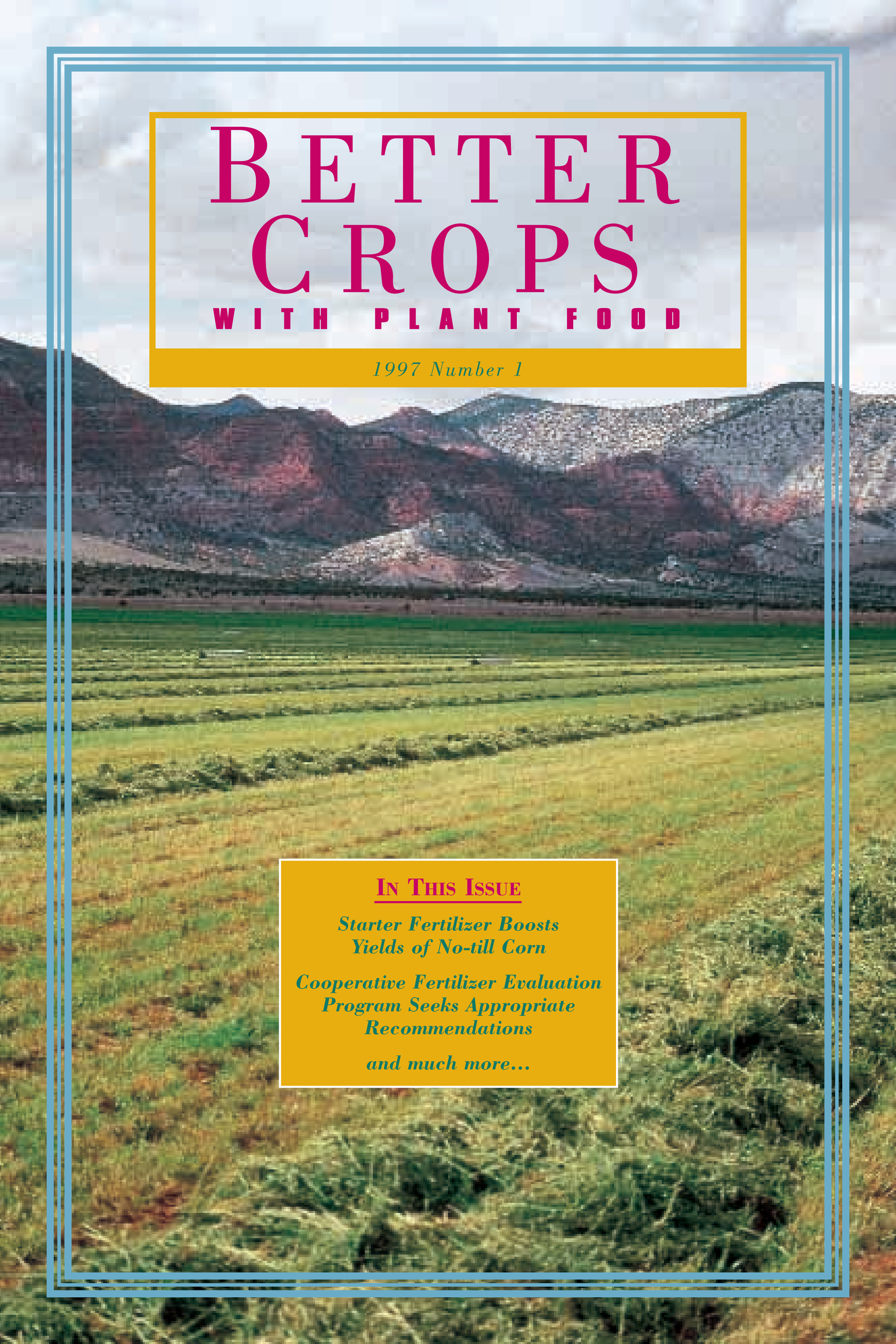


BETTER CROPS WITH PLANT FOOD

1997 Number 1

In This Issue

Starter Fertilizer Boosts Yields of No-till Corn

Cooperative Fertilizer Evaluation Program Seeks Appropriate Recommendations

and much more...

BETTER CROPS WITH PLANT FOOD

Vol. LXXXI (81) 1997, No. 1

Our Cover: Alfalfa harvest in the Sevier Valley of central Utah (Red Rock Cliffs in background).
Cover Photo: Dr. A.E. Ludwick

BETTER CROPS WITH PLANT FOOD
(ISSN:0006-0089) is published quarterly by the Potash & Phosphate Institute (PPI). Periodicals postage paid at Norcross, GA, and at additional mailing offices (USPS 012-713). Subscription free on request to qualified individuals; others $8.00 per year or $2.00 per issue. POSTMASTER: Send address changes to **Better Crops with Plant Food**, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837. Phone (770) 447-0335; fax (770) 448-0439.

CONTENTS

Charles O. Dunn Elected Chairman, John M. Van Brunt Vice Chairman of PPI and FAR Boards of Directors

Charles O. Dunn, President and CEO, Mississippi Chemical Corporation (MCC) was elected Chairman of the PPI Board of Directors at a recent meeting. He will also serve as Chairman of the Foundation for Agronomic Research (FAR) Board of Directors. John M. Van Brunt, President and CEO, Agrium Inc., is the new Vice Chairman of the PPI and FAR Boards.

Charles O. Dunn

"We sincerely welcome these respected industry leaders to their key roles with the PPI and FAR Boards," said Dr. David W. Dibb, President of PPI.

Mr. Dunn has served as President and Chief Executive Officer of MCC since 1993. A native of Mississippi, he received his B.A. degree with honors in 1970 from The Citadel in Charleston, South Carolina. After serving as an officer with the U.S. Army, he attended the University of Alabama School of Law, graduating in 1975. He practiced law in Atlanta, Georgia, before joining MCC in 1978 at company headquarters in Yazoo City, Mississippi.

John M. Van Brunt

In 1984, Mr. Dunn transferred to the Finance Division as Director of Taxes and Financial Services. He was promoted to Vice President of MCC in 1986 and to Executive Vice President and Chief Operating Officer in 1989.

Mr. Van Brunt was appointed President and Chief Executive Officer of Agrium Inc. (formerly known as Cominco Fertilizers) in January 1993 and has guided the company through a number of strategic growth initiatives. He attended Queen's University in Kingston, Ontario, and received his BSc in chemical engineering in 1965. He began work with Cominco Ltd. and served in a series of positions in production, operations, and industrial relations. In 1985, he was named Vice President, Operations, and in 1991 became Senior Vice President and Chief Operating Officer, Cominco Fertilizers, Calgary, Alberta.

In other action of the PPI Board, John H. Sultenfuss, Senior Vice President, Marketing and Sales, CF Industries, Inc., was elected Chairman of the Finance Committee.

In action of the FAR Board of Directors, Dr. Harold F. Reetz, PPI Midwest Director, was named Vice President. Also, Mr. G.J. Quinn of Zeneca Ag Products and Dr. Paul E. Fixen, Senior Vice President of PPI, joined the FAR Board of Directors. BC

IDAHO

Cooperative Fertilizer Evaluation Program Seeks Appropriate Recommendations

By Terry A. Tindall and Jeffrey C. Stark

The basis for university recommendations on rates, timing and types of fertilizer to be used in a given area is usually developed from research by university, USDA/ARS, and other government researchers with little direct input from growers or industry.

Because of constantly changing cropping systems, advances in plant genetics, improved irrigation management, and other factors, fertilizer guidelines must be updated periodically to remain current. In recent years, growers, fieldmen, and consultants in Idaho have expressed significant concern regarding the adequacy of university fertilizer recommendations for present management systems and yield levels. Many claim that they get higher yields and net economic returns by applying higher fertilizer rates than those predicted from small plot fertilizer research results. To a large extent, this perceived need to apply higher fertilizer rates results from growers' efforts to address problems associated with soil variability. Fertilizer response calibrations obtained from sites with low variability (such as small research plots) typically underpredict the optimum fertilizer rate for fields with high variability.

Cooperation of university, industry and growers is leading to more adequate guidelines for fertilizer recommendations in Idaho. This article reports the progress after four years of work to develop broad-based criteria for nutrient management in major crops of the state.

A primary concern of growers relates to the policy adopted by the Natural Resources Conservation Service in Idaho which, in conjunction with other agencies, developed the Nutrient Management Technical Guide. It imposes specific limitations regarding the rates of nitrogen (N) and phosphorus (P) that growers participating in government subsidy programs can apply to their crops. The limitation is equivalent to 1.2 times the University guidelines. If guidelines are inadequate, this program could cause serious production losses for participants.

Examining CFEP potato plots during the 1996 season are, from left: Bob Adams, private consultant; Dr. T.A. Tindall, University of Idaho; and Rocky Duncan, potato grower.

TABLE 1. Original University of Idaho P fertilizer guide for Russet Burbank potatoes based on soil test P, percent free lime and yield goal.

Soil test P[1] 0-12 inch depth	Preplant P fertilizer recommendation Percent free lime[2] Less than 5%	10%	15% or more
	pounds P_2O_5 per acre		
0	240	354	466
5	160	280	400
10	80	200	320
15	0	120	240
20	0	40	160
25	0	0	80
30	0	0	0

[1]Soil extractant for P is sodium bicarbonate ($NaHCO_3$); ppm.
[2]Free lime is measured as calcium carbonate equivalent (CCE).

Program Background

The Cooperative Fertilizer Evaluation Program (CFEP) was initiated in the spring of 1993 through joint university and industry efforts with the following objectives:

1) Increase the scientific database from which nutrient decisions are made.

2) Build cooperative relationships among the University of Idaho, growers and the fertilizer industry by providing joint ownership of newly developed fertilizer guides.

3) Provide growers with more broad-based, well-defined criteria that combine both on-farm and agricultural experiment station information.

4) Promote environmental responsibility based on research as opposed to opinion.

The 1996 season concluded four years of CFEP programs for all major Idaho crops. There has been tremendous support for the program from grower groups, the fertilizer industry, and state and federal agencies. The total number of CFEP plots initiated to date is over 150. These figures represent a tremendous amount of work by growers and those fieldmen responsible for coordinating and gathering much of the information. Costs to date total about $250,000.

All experimental plots were conducted on commercial fields utilizing growers' normal farming practices. The only variable was the type and rate of nutrient applied. Each location had an initial soil sample taken. Nitrogen, P, or potassium (K) was applied at rates that represented a range from zero up to 2 to 3 times the recommended rate, based on soil analysis.

Plot sizes were substantially greater than traditional research plots. Fertilizer treatments were typically applied in 50 to 100 ft. strips across the entire length of the field. Sites were selected from cooperators who were considered excellent growers. Each site coordinator was asked to keep track of all inputs and production data on a standardized CFEP worksheet. At the end of the season, plots were harvested with commercial harvesting equipment and subsamples were collected to determine grade and quality.

The authors were very pleased with the tremendous effort put forth by the individual site coordinators. Their cooperation cannot be over emphasized. The fact that this is truly a unified effort is a key factor in the success of the CFEP program.

Results

After completion of four years of experimentation on growers' fields and across many locations and soil types, the data indicated that there was adequate justification for revising the fertilizer guides for some of the major crops.

Phosphorus can be used as an example of the potential need for modifying current fertilizer guides. **Table 1** gives the earlier University of Idaho P recommendations

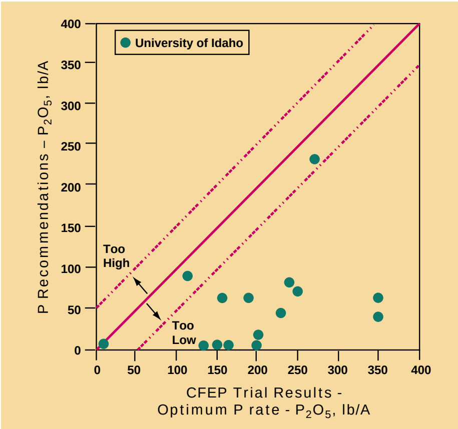


Figure 1. Original University of Idaho fertilizer P recommendations in relationship to the 1993-96 CFEP potato projects.

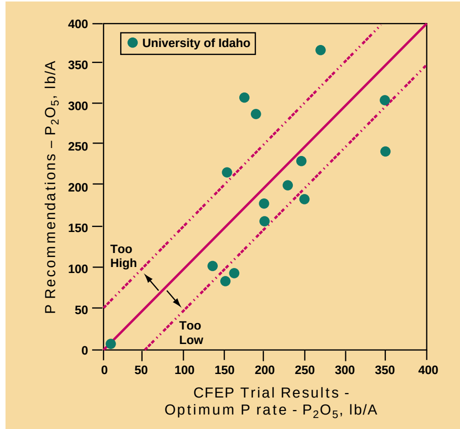


Figure 2. Revised University of Idaho fertilizer P recommendations in relationship to the 1993-96 CFEP potato projects.

for irrigated potatoes. This information takes into account soil test P levels and percent free lime.

Figure 1 shows the relationship between the present University of Idaho potato P recommendations for each of 15 CFEP field trials and the corresponding P fertilizer rates that produced the highest yield in each trial. The line intersecting zero represents a 1:1 relationship between fertilizer P recommendations (Y-axis) and corresponding optimum P rates. The dashed lines represent plus or minus 50 lb/A of P_2O_5 that should serve as a reasonable target for commercial operations.

Those fertilizer recommendations that fall below the lower dashed line are considered insufficient and those above the upper dashed line are considered excessive. The University recommendations were low at nearly all levels of recommended fertilizer P. In fact, all but two

TABLE 2. Revised University of Idaho P fertilizer guide for Russet Burbank potatoes based on soil test percent, free lime and yield goal.

Soil test P[2] 0-12 inch depth	Preplant P fertilizer recommendation[1] – Percent free lime[3]: 0	2	4	6	8	10	12	14
	pounds P_2O_5 per acre							
0	320	340	360	380	400	420	440	460
5	240	260	280	300	320	340	360	380
10	160	180	200	220	240	260	280	300
15	80	100	120	140	160	180	200	220
20	0	20	40	60	80	100	120	140
25	0	0	0	0	0	20	40	60
30	0	0	0	0	0	0	0	0

[1]Apply an additional 80 to 100 lb of P_2O_5/A as a starter at planting to any soil test P value below 31 ppm.
[2]Soil extractant for P is sodium bicarbonate ($NaHCO_3$); ppm.
[3]Free lime is measured as calcium carbonate equivalent (CCE).
Increase P_2O_5 application by 10 lb/A for each % lime increase.
[4]Recommendations are based on 400 cwt/A yield goal. Add 25 lb P_2O_5/A for each additional 100 cwt/A increase in the yield goal above 400 cwt/A and subtract 25 lb P_2O_5/A for each 100 cwt/A decrease below 400 cwt/A.

points fell below the target range. The differences between P recommendations and optimum P rates were substantial when P requirements were high.

The University of Idaho has developed a revised P fertility guide for potatoes (**Table 2**). The primary changes included in the revised recommendations are 1) raising the soil P sufficiency level from 15 to 20 ppm $NaHCO_3$-extractable P, 2) making the adjustment for percent free lime linear across all lime levels (10 lb P_2O_5 for each 1 percent increase in free lime), 3) recommending a starter application of 80 to 100 lb P_2O_5/A, and 4) providing an adjustment for yield goal based on differences in crop P removal.

Figure 2 compares the new P fertilizer recommendations to the results of the CFEP trials. The revised recommendations are in reasonably good agreement with the optimum P rates. Much of the variability may be due to the fact that the intervals between P rates for most of the trials were greater than 50 lb P_2O_5/A. Additional data from on-farm research and traditional small-plot fertilizer trials were also used to validate the revised recommendations.

The CFEP program provides good information that can be utilized to evaluate where we are in soil and tissue test correlation. It is also a means to interact with grower groups and the fertilizer industry in developing meaningful and usable guidelines. The program will continue into the foreseeable future, adjusting to current needs.

Dr. Tindall is Extension Soil Scientist, University of Idaho, Twin Falls. Dr. Stark is Research Agronomist, University of Idaho Research Extension Center, Aberdeen.

Alabama: Phosphorus Availability from Phosphate Rock as Enhanced by Water-Soluble Phosphorus

The objective of the study was to distinguish phosphorus (P) availability from the soil, central Florida phosphate rock (PR) and triple superphosphate (TSP) so that P uptake by crops from the PR in the presence of TSP could be estimated. Radioactive 32P was used as a tracer.

Three sets of silt loam samples were mixed with (1) 32P solution and PR, (2) 32P-tagged TSP and (3) 32P-tagged TSP and PR at a 50:50 ratio. Phosphorus rates were 0, 12.5, 25, 50, 100 and 200 parts per million (ppm). An additional rate of 400 ppm was prepared for treatment (3). Corn and cowpea were planted, then harvested after 42 and 45 days, respectively.

The effectiveness of P source in terms of increasing dry matter yield and P uptake was TSP > (PR + TSP) > PR for corn and TSP = (PR + TSP) > PR for cowpea. Uptake of P from PR in the presence of TSP was higher than when PR was applied alone, indicating an enhancement effect on PR uptake by the TSP.

Source: S.H. Chien, R.G. Menon and K.S. Billingham. 1996. Soil Sci. Soc. Am. J. 60:1173-1177.

KANSAS

Cool Season Grasses Need Phosphorus

By R.E. Lamond and K.C. Dhuyvetter

Cool season grasses are an important forage resource. They have the potential to produce high yields of quality forage when managed properly. Optimum production of quality forage requires application of nitrogen (N) fertilizer. A significant acreage of established cool season grasses has been in production (grazing and/or hay) in Kansas for 10 to 20 years or more. Complaints of reduced production on these established grasses are common.

Kansas research emphasizes the importance of adequate phosphorus (P) in bromegrass fertilization. Production of higher yields of good quality forage ... and higher profitability ... depends on providing needed P.

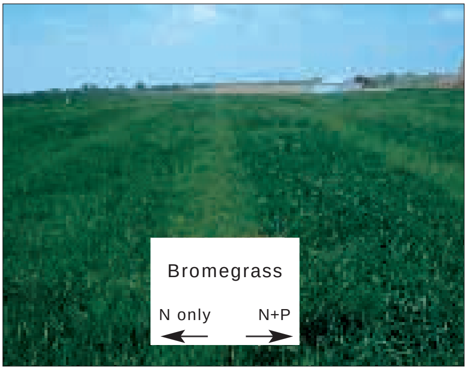
Why are yields falling? Soil testing often shows that problem pastures have low soil P levels. These low soil P levels exist because P has frequently been overlooked as part of the overall nutrient management plan.

Like alfalfa, cool season grass forages are heavy users of P. Each ton of grass produced removes 8 to 12 lb P_2O_5/A. For example, a bromegrass pasture that produces 3 tons/A of hay would remove about 30 lb P_2O_5/A. Since N is the major component of cool season grass fertilization programs, the need for P is sometimes neglected. On soils high in P, fertilization with N alone initially produces excellent yields of high-quality forage. However, after several years of good forage production without P fertilization, soil test P values drop rapidly and P becomes the limiting factor. Unless P is included in the nutrient management program, forage production potential drops and poor N use efficiency results.

Phosphorus-deficient pastures and meadows are characterized by thin stands and increasing levels of undesirable invading species that seem to thrive on low P soils. A routine soil test can easily determine if P is limiting. When low soil P is confirmed, fertilizer P application is critical for optimum production.

Kansas Research

Recent research in Kansas confirms the importance of P as a critical part of a cool season grass fertilization program (**Table 1**). Nitrogen rates (40, 80, 120



Cool season forage grasses such as bromegrass and tall fescue require adequate P for acceptable yields. Bromegrass plants shown on left received N only, those on the right received N plus P.

TABLE 1. Phosphorus fertilization increases bromegrass yields and N use efficiency.[1]

N, lb/A	P_2O_5, lb/A	Miami Co. Yield lb/A	Miami Co. N use eff.[2] %	Douglas Co. "A" Yield lb/A	Douglas Co. "A" N use eff. %	Douglas Co. "B" Yield lb/A	Douglas Co. "B" N use eff. %
0	0	2,560	—	2,960	—	3,040	—
40	0	3,490	30	4,440	35	5,900	58
80	0	4,450	38	6,180	48	6,970	48
120	0	4,570	32	6,330	43	8,010	45
40	30	5,100	60	6,690	80	9,070	133
80	30	5,510	45	7,570	64	9,170	70
120	30	6,160	45	7,580	45	9,690	63
LSD (0.05)		1,240	11	1,110	13	980	17

[1]Soil P (Bray 1): Miami County = 6 lb/A (very low), both Douglas County sites = 7 lb/A (very low).

[2]N use efficiency = $\frac{\text{N uptake by specific treatment - N uptake of check plot}}{\text{N applied on a specific treatment}}$

lb/A) and P rates (0, 30 lb P_2O_5/A) were evaluated at three low P sites using urea and triple superphosphate, topdressed in late February. Phosphorus fertilization increased bromegrass yields significantly at all sites and at all N rates. Averaged across N rates and sites, application of 30 lb P_2O_5/A increased forage yields by 1,800 lb/A. At $70/ton for brome hay and $0.30/lb P_2O_5, this represents a return of $63 for a $9 investment. Nitrogen use efficiency was also significantly increased by P fertilization. Averaged over N rates and sites, N use efficiency was increased from 42 percent to 67 percent with application of 30 lb P_2O_5/A, clearly illustrating the point that N use efficiency will be poor on low P soils until P is applied.

In summary, P fertilization is a key component of cool season grass productivity and profitability. BC

Dr. Lamond is Soil Fertility Soil Management Specialist and Mr. Dhuyvetter is Northeast Area Extension Ag Economist, Kansas State University, Manhattan, KS.

Annual Statement of Ownership

Statement of ownership, management, and circulation (required by 39 U.S.C. 3685) of Better Crops with Plant Food, published four times a year at 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837, for October 1, 1996. General business offices of the publisher are located at 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837. Name and address of publisher is Potash & Phosphate Institute, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837. Name and address of editor is Donald L. Armstrong, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837. There is no managing editor. Owner is Potash & Phosphate Institute, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837. There are no known bondholders, mortgagees, or other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities. The average number of copies of each issue during the preceding 12 months is: (a) Total number of copies printed: 20,648; (b) Paid circulation: (1) Sales through dealers and carriers, street vendors, and counter sales: 5,954; (2) Paid or requested mail subscriptions: 9,676; (c) Total paid and/or requested circulation: 15,630; (d) Free distribution by mail: 2,464; (e) Free distribution outside the mail: 116; (f) Total free distribution: 2,580; (g) Total distribution: 18,210; (h) Copies not distributed: (1) Office use, leftovers, spoiled: 2,438; (2) Return from news agents: not applicable; (i) Total: 20,648; Percent paid and/or requested circulation: 85.8%. The actual number of copies of single issue published nearest to filing date is: (a) Total number of copies printed: 22,120; (b) Paid circulation: (1) Sales through dealers and carriers, street vendors, and counter sales: 6,377; (2) Paid or requested mail subscriptions: 9,676; (c) Total paid and/or requested circulation: 16,053; (d) Free distribution by mail: 2,290; (e) Free distribution outside the mail: 1,407; (f) Total free distribution: 3,697; (g) Total distribution: 19,750; (h) Copies not distributed: (1) Office use, leftovers, spoiled: 2,370; (2) Return from news agents: not applicable; (i) Total: 22,120; Percent paid and/or requested circulation: 81.3%. I certify that all information furnished above is true and complete. I understand that anyone who furnishes false or misleading information on this statement or who omits material or information requested on the statement may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including multiple damages and civil penalties).

Donald L. Armstrong, Editor

KANSAS

Phosphorus Benefits Grain Sorghum on Acid Soils

By R.E. Lamond, A.J. Suderman, D.A. Whitney, S.R. Duncan and T.L. Wesley

Kansas and Oklahoma research has demonstrated the need for liming for wheat production on acid, high potassium chloride (KCl) extractable aluminum (Al) soils by increasing soil pH and reducing exchangeable Al levels. Banding P with the seed has also been shown to be an effective management alternative for improving wheat production when liming is not possible, even on very high P testing soils. Banded P forms complexes with Al, taking the Al out of soil solution, lowering the toxicity to plants and allowing plants to grow in acid soils where acidity may be largely confined to surface soil layers. The Kansas and Oklahoma research showed that wheat variety selection was also critical, because considerable differences exist among varieties in their tolerance of Al toxicity.

When liming is not possible, banding phosphorus (P) with grain sorghum seed at planting is an effective short-term management option on acid soils even with very high P soil tests.

Research was initiated in Kansas in 1995 to evaluate liming and P fertilization to improve grain sorghum production on acid, high KCl-extractable Al soils. Responses in the first two years have mirrored those observed earlier with wheat.

Results are summarized in **Table 1**. Lime responses were variable in 1995. Lime was applied only 10 days prior to planting, with minimal incorporation. Banded P responses occurred across all lime rates. Banding 35 lb P_2O_5/A with the seed at planting increased grain yield and test weight and reduced grain moisture at harvest even though Bray-1 P soil test was very high. Banded P reduced concentrations of soil Al. The site had a soil pH of 4.6, KCl-extractable Al of 55 parts per million (ppm), and a Bray-1 P level of 47 ppm.

TABLE 1. Phosphorus is highly effective in increasing grain sorghum yields on acid soils.

Lime rate, lb ECC/A	P_2O_5, lb/A	Yield, bu/A 1995	Yield, bu/A 1996	Grain moisture,[1] %	Test weight,[1] lb/bu
0	0	72	39	15.2	57
0	35 Band	106	45	11.6	61
5,000	0	75	52	14.5	58
5,000	35 Band	106	59	11.7	61
10,000	0	85	61	13.9	58
10,000	35 Band	110	61	11.7	61
LSD (0.05)		17	8	2.6	2

[1]Grain moisture and test weight data are for 1995 only.

The 1996 yields were low for all treatments due to dry weather conditions during the growing season. Even under dry conditions in 1996, response to banded P occurred only where no lime or the 5,000 lb effective

GRAIN SORGHUM, like wheat, responds to starter P on acid (pH 4.6), high P soils. Plants on the right received 35 lb P_2O_5/A banded in direct seed contact. Banded P helps lower Al toxicity in the vicinity of the seedling.

calcium carbonate (ECC)/A rate had been applied.

A companion study recorded large differences in the performance of grain sorghum hybrids under these acid soil conditions. BC

The authors are with Kansas State University, Manhattan, KS.

Production Notes

Fescue Needs Phosphorus

Fertilizing with phosphorus (P) in early March can significantly boost tall fescue production and reduce chances of grass tetany, a paralyzing disease of cattle.

University of Missouri research shows 25 lb/A of P applied during the first week in March increases tall fescue production by more than 1,000 lb/A at the first cutting in mid May.

Also, the forage is higher in quality in terms of more magnesium (Mg), calcium (Ca) and P for grazing animals. In other words, the fescue is no longer tetany-prone.

About two-thirds of Missouri forage acres have problems with low-P soils. Based on soil test data, more than 60 percent of these pastures need P fertilization in order to increase hay yield by 1,000 lb/A. With tall fescue hay worth $40/ton, this effort is worth more than $140 million to producers in the state in terms of fescue yields, plus the reduction in grass tetany disease.

The complex set of problems associated with grass tetany usually boils down to low Mg and Ca in the diet of cows in the late winter and early spring. Laboratory research revealed that the P concentration around the roots was a major factor in controlling the uptake of Mg and Ca into grass plants. Further work in the greenhouse showed uptake of these two important nutrients and their movement from roots to leaves was dependent on the P nutrition of the plant.

Field studies showed that the addition of 25 lb/A of P resulted in significant increases in Mg and Ca concentrations of tall fescue leaf blades in late March and throughout April. BC

Source: Dr. Dale Blevins, Professor of Agronomy, College of Agriculture, Food and Natural Resources, University of Missouri, Columbia. This research was supported in part by PPI and the Foundation for Agronomic Research (FAR).

ILLINOIS

Starter Fertilizer Boosts Yields of No-till Corn

By R.G. Hoeft and K.B. Ritchie

Fertilizer management is affected by tillage because aglime and immobile nutrients such as phosphorus (P) and potassium (K) move slowly in most soils when not mixed by tillage. Such nutrients tend to stratify near the soil surface. While the stratification has been documented in a number of studies, it has not been shown to reduce yields of corn and soybeans in Illinois. Limited research does indicate that plants develop more roots near the surface in conservation tillage systems, apparently due to increased levels of surface residues and higher levels of available nutrients.

Conditions for early growth of no-till corn often involve cool soil temperatures and high soil moisture due to residue cover from the previous crop. Illinois research continues to show advantages of starter fertilizer placed 2 inches to the side and 2 inches below the seed in no-till corn production.

Starter fertilizer is more effective than broadcast applications under cool, moist conditions when P soil tests are low, irrespective of tillage system. At high levels, starter fertilizer often results in early growth response on conventional tillage systems, but seldom results in increased yield at harvest.

Early season growth of no-till corn is frequently less vigorous than conventional tillage. This slower growth is likely the result of cooler soil temperatures and higher soil moisture conditions associated with the high residue mulch. Both of these conditions tend to slow root growth and thus the ability of the plant to absorb nutrients.

In a 3-year study at four locations in Illinois, starter fertilizer placed 2 inches below and 2 inches to the side of the seed increased grain yield at 10 of the 11 site years (**Table 1**). Study results revealed several important considerations when deciding whether to use starter fertilizer for no-till corn.

• Nitrogen (N) provided the majority of the response at Ashton, Pana, and Oblong sites. The table does not show this for Oblong, but the individual year data show that N was the most important

TABLE 1. Effect of starter fertilizer on grain yield of no-till corn.

Starter fertilizer lb/A			Location/previous crop			
N	P_2O_5	K_2O	Ashton/corn	Gridley/soybean	Pana/soybean	Oblong/soybean
			Yield, bu/A			
0	0	0	131	120	128	146
25	0	0	141	123	136	150
25	30	0	147	129	139	155
25	30	20	146	137	133	160

No-till corn production may benefit from starter fertilizer, particularly if cool, moist conditions prevail or if soil test P levels are low.

element in 2 of the 3 years.

• Addition of P with the N increased yield more than enough to pay for the P. This was true even at Ashton, which had a Bray P test level in excess of 90 lb/A.

• Including K in the starter did not significantly affect yield at either Ashton or Pana. At the other two locations, K did have a significant impact in 1 of the 3 years of the study. At Gridley, the increase from K occurred in a year with a wet spring, which resulted in delayed planting, followed by very dry conditions during early plant growth. Since this was a long-term no-till field, the inherent K was primarily in the upper inch of the soil profile, where root activity was limited during the dry period. There was adequate moisture at the 4-inch depth for good root activity and K uptake from the fertilizer band. At Oblong, soil test K was low. In the year in which K was not broadcast prior to planting, there was good response to K in the starter. However, in the other 2 years, when K was broadcast, there was no response to starter K.

Getting yield response with other starter application methods met with limited success. While placement of N at rates up to 10 lb/A directly with the seed increased yield, the increase was not as consistent as with the 2x2 starter. And, in a dry spring, placement of as little as 10 lb/A of N significantly reduced stand in some experiments. Band placement of N (25-0-0) or N plus P (25-30-0) on the soil surface near the seed row resulted in higher average yields than with no starter, but not as high or consistent as with banded NPK treatments. BC

Dr. Hoeft is Professor, Soil Fertility Extension, and Mr. Ritchie is Jonathan Baldwin Turner Fellow, Department of Crop Sciences, University of Illinois.

OKLAHOMA

Small-Scale Variation in Soil Test Phosphorus and Bermudagrass Yield

By W.R. Raun, J.B. Solie, G.V. Johnson, M.L. Stone, R.W. Whitney, H.L. Lees, H. Sembiring and S.L. Taylor

Precision farming has the potential to become an integral part of production agriculture, impacting growers, fertilizer dealers, equipment manufacturers, environmental groups, and others. Recent work in precision agriculture has used yield maps as keys to identifying spatial variability in crop production systems without generally questioning the resolution at which yield maps are generated. Present day yield maps that use the Global Positioning System (GPS) are generated at a resolution of approximately 30x30 ft. The exact size is defined by the width of the combine header. In general, the 'precision farming' resolution has not been driven by what was agronomically needed or economically advantageous, but by what was technologically available.

A recent Oklahoma study looked at the challenges of determining variability of fertility in small areas of fields and adapting management accordingly. More research is needed to develop accurate and practical methods for measuring variability in fields.

Field element size can be defined by the area which provides the most precise measure of the available nutrient where the level of that nutrient changes with distance. Our recent research has indicated that variable rate technology which treats field elements greater than 21 sq. ft. will likely not optimize fertilizer nitrogen (N) inputs while having the potential for misapplying fertilizers as a result of using too coarse a grid.

In conventional production systems, field element size should theoretically meet the following criteria;

1. Identify the smallest practical resolution where cause and effect relationships can be measured.
2. Identify the precise resolution where variances between paired samples of the same size (area) become unrelated (use of semivariograms).

Two established bermudagrass pastures were identified and a visually homogenous 7x70 ft. area was selected for intensive forage and soil sampling. For the past ten years, no fertilizer was applied at either site and bermudagrass has been grown continuously. However, the Burneyville site has been used for infrequent cattle forage. Both sites were considered to be N responsive. Each 7x70 ft. area was partitioned into 1x1 ft. plots (490 subplots), subsequently harvested and soil sampled (8 cores/plot 0-6 inches deep). Soil samples were analyzed for pH, phosphorus (P) and potassium (K).

Prior to forage harvest, spectral radiance readings were assessed from each 1x1 ft. subplot using a sensor developed at Oklahoma State University, and which has since been modified for use on a variable rate N applicator. Photodiode detectors and interference filters for red (671 ± 6 nm), green (550 ± 6 nm) and near

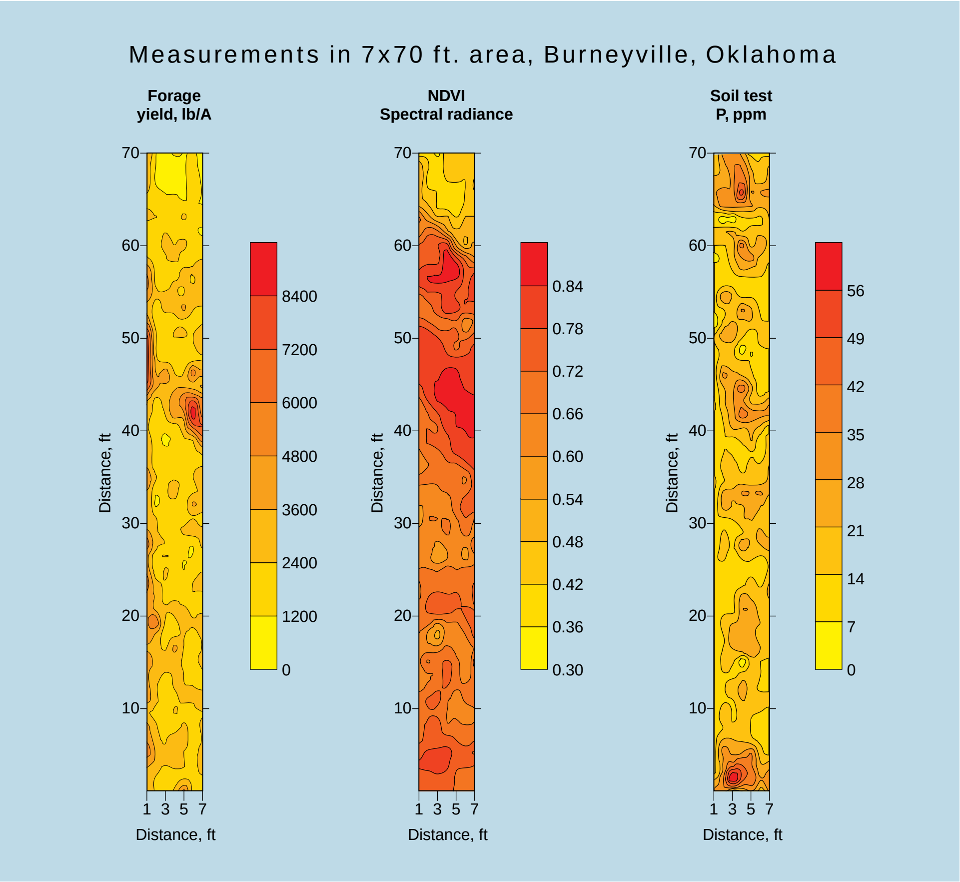


Figure 1. Surface contour maps of bermudagrass forage yield, spectral radiance measurements... normalized-difference-vegetation-index (NDVI)...taken prior to harvest, and soil test P from a 7x70 ft. area sampled on a 1x1 ft. grid, Burneyville, Oklahoma.

infrared (NIR, 780 ± 6 nm) spectral bands were used. The normalized-difference-vegetation-index (NDVI) was calculated where NDVI = (NIR-red)/(NIR+red).

At both locations, bermudagrass forage yield harvested from 1x1 ft. plots ranged from less than 1,000 to greater than 9,000 lb/A equivalent. This is illustrated in a surface contour map at Burneyville (**Figure 1**).

Finding a 10-fold difference in yield within a 490 sq. ft. area at both sites was alarming considering that the precision error in estimating yield (precision of scale for wet and dry weights and harvest area error) was small. As can be seen in the NDVI contour map from spectral data collected from each 1x1 ft. plot at Burneyville, this parameter resulted in similar patterns as that noted for forage yield. Other researchers have also demonstrated strong correlation between NDVI and plant biomass.

Mean soil test P values were 18 and 42 parts per million (ppm) at Burneyville and Efaw, respectively (**Table 1**). Similar to forage yield, variability in soil test P within the 490 sq. ft. was large, as is illustrated at Burneyville (range of 3 to 124 ppm, **Table 1** and **Figure 1**). The mean soil test P of 18 ppm at Burneyville was in excess of 80 percent sufficiency for bermudagrass production. At this level, only 20 lb of P_2O_5 fertilizer would have been recommended. However, larger fertilizer P rates would have been required when observing micro-scale variability evidenced in significant portions within the 490 sq. ft. area. Fertilizer P recommendations based on the extractable P levels reported would have ranged from 0 to 60 lb P_2O_5/A at Burneyville. Although graphic data are not reported, soil pH ranged from 4.37 to 6.29 within the 490 sq. ft. area at Burneyville. The mean soil pH was near 5.5 at both sites, but several values were below 4.5 at Burneyville (**Table 1**). At this pH, aluminum (Al) and/or manganese (Mn) in soil solution can increase to toxic levels. Thus, lime would be required in these areas to alleviate the toxicity. Similar variability in soil test and forage yield parameters has been found at other monitored sites.

The 7x70 ft. areas that were sampled on a 1x1 ft. grid in this research were used to identify the resolution where real differences in both soil test and yield parameters could be detected. They were not intended to be 'representative' of the range in variability found in each field, but rather indicators of the fixed area where 'real' differences can be found within that field. At present, our research is showing that field element size (measure of the available nutrient where the level of that nutrient is related with distance) will seldom exceed 21 sq. ft.

Finally, it is important to note that when farmers collect 15 to 20 random cores (0 to 6 or 0 to 8 inch depth) from a field, the composite sample often provides an accurate estimate of the mean soil test nutrient level in that field. However, the mean soil test nutrient level does not address the variability encountered in that field. Because micro-variability has been found to be so great in some fields, soil sampling the variability in those fields would not be affordable. For precision agriculture to treat most of the variability encountered in such agricultural fields, accurate and inexpensive indirect measures will be needed that account for the variability. BC

Acknowledgments: This work was supported in part by the Samuel Roberts Noble Foundation, Ardmore, Oklahoma and by PPI/FAR. The authors are with the Department of Agronomy, Oklahoma State University.

TABLE 1. Mean, standard deviation, minimum and maximum values for forage yield and soil analyses from 1x1 ft. plots, Burneyville and Efaw.

Burneyville	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Forage yield, lb/A	2,593	1,420	218	9,598
Soil pH	5.44	0.22	4.37	6.29
Soil P, ppm	18.4	9.6	3.1	124.1
Soil K, ppm	130.2	37.6	13.0	262.0
NDVI	0.685	0.119	0.331	0.909
Efaw	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Forage yield, lb/A	6,556	3,448	1,090	21,379
Soil pH	5.81	0.19	5.37	6.34
Soil P, ppm	41.8	9.6	15.2	63.7
Soil K, ppm	131.4	38.4	12.0	301.0
NDVI	0.530	0.044	0.373	0.667

ALBERTA

Soil Testing Methods Calibrated to Phosphate Fertilizer Trials

By R. H. McKenzie and Len Kryzanowski

Extensive P fertilizer calibration trials were conducted in Alberta in response to concern about the accuracy of P soil test methods. Replicated trials with wheat, barley and canola were conducted on major soil types across Alberta from 1991 to 1993. Response data were collected from 427 sites. Based on a minimum two bushel yield difference between the control and the P treatments, 81 percent of wheat sites, 90 percent of barley sites and 72 percent of canola sites responded to P fertilization.

The purpose of our study was to improve P fertilizer recommendations in the province and other areas of the prairies. Several P soil test methods currently in use in western Canada were evaluated for their ability to predict wheat and barley response to seed-placed P and canola response to seed-placed and banded P. Some of these are listed in **Table 1**. The Miller-Axley was the standard method used in Alberta and the Olsen test was routinely used in Saskatchewan and Manitoba. The Kelowna and modifications of this method (i.e. Norwest and Saskatchewan) were developed in recent years because the Miller-Axley and Olsen tests did not appear to work effectively across a wide range of soils.

A recent study has clearly demonstrated the need for phosphorus (P) fertilizer in Alberta, suggesting 50 to 80 percent of the soils in the province are marginally to severely deficient in P. It has also provided valuable calibration information for several P soil tests which are in use across Western Canada.

Several mathematical models were tested to correlate relative yield (control yield divided by the highest yielding P treatment) with extractable P based on the different soil test methods. **Figure 1** gives an example of the model that proved the most successful using wheat data versus the Kelowna P test. Curves were fitted for each crop, each soil zone and for each soil test method.

TABLE 1. Soil test P methods evaluated in P calibration trials in Alberta.

Method	Extractant
Miller and Axley	ammonium fluoride and sulfuric acid (0.03N NH_4F + 0.03N H_2SO_4)
Olsen	sodium bicarbonate (0.5M $NaHCO_3$)
Kelowna	acetic acid and ammonium fluoride (0.25N HOAc + 0.015N NH_4F)
Norwest	acetic acid, ammonium fluoride and ammonium acetate (0.5N HOAc + 0.015N NH_4F + 1.0N NH_4Oac)
Saskatchewan	acetic acid, ammonium fluoride and ammonium acetate (0.25N HOAc + 0.015N NH_4F + 0.25N NH_4Oac)

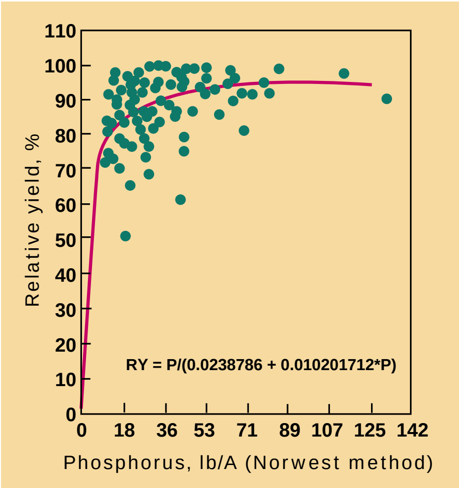


FIGURE 1. Correlation of relative wheat yield with soil test P using the Norwest method. (Alberta)

Figure 1 shows the relative yield for wheat did not reach 100 percent (i.e. no difference between the control and maximum yield) until the soil test P level was about 27 lb/A. However, even at that level, 90 percent of the sites still responded to applied P. Whenever soil test P was 18 lb/A or less, almost all sites had relative yields less than 100 percent. As soil test P levels increased, the frequency of 100 percent relative yield also increased. However, even at soil test levels greater than 53 lb/A there were still sites that did not reach 100 percent relative yield and were still responsive to added P fertilizer.

The frequency of P response in wheat at all sites and its relationship to soil test P by the various methods are illustrated in **Figure 2**. The methods differed in their ability to predict P response, most notably at the lowest soil test level. The three methods which use ammonium fluoride and acetic acid in their extracting solutions successfully predicted 100 percent P response when soil P was between 0 and 9 lb/A. The other two methods did not perform as well. They correctly predicted a response in only 40 to 60 percent of the sites at this lowest soil test level. This is not surprising as soil characteristics (e.g. pH and carbonates) can vary widely over the province, which would limit the effectiveness of some extraction methods.

The Norwest method is the most commonly used in Alberta. About 88 percent of all wheat (128 of 144 sites), barley (140 of 159 sites) and canola (110 of 125) sites tested less than 53 lb/A (0 - 6 inch) using this method. And, a significant number of sites testing high in available P (i.e. > 53 lb/A) had a relative yield less than 100

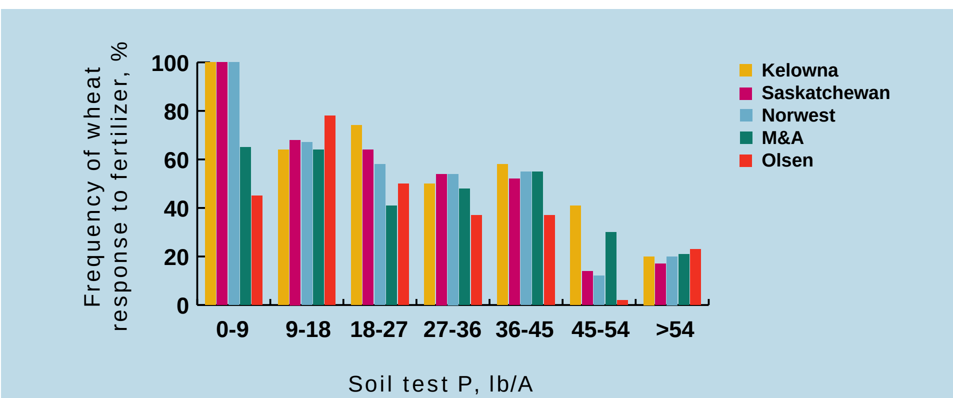


FIGURE 2. Frequency of wheat response to P fertilizer at various soil test levels as determined by several methods. (Alberta)

TABLE 2. Phosphorus fertilizer recommendations for spring wheat on a medium to fine textured soil with a neutral pH based on the Kelowna method.

Soil test P, lb/A 0 to 6 inches	P_2O_5 recommended, lb/A					
	Brown Soil Zone			Black Soil Zone		
	D	M	W	D	M	W
0 - 9	27	31	36	36	40	45
9 - 18	22	27	31	31	36	40
18 - 27	18	22	27	27	31	36
27 - 36	13	18	22	22	27	31
36 - 45	13	13	18	22	22	27
45 - 54	13	13	18	18	18	27
54 - 62	13	13	13	13	13	22
62 - 71	0	13	13	0	13	18
71 - 80	0	0	13	0	0	13
> 80	0	0	0	0	0	0

Seedbed moisture conditions at planting: dry (D) = 25%, medium (M) = 50% and wet (W) = 75% of field capacity.

percent, indicating that response to added P had occurred. In fact, 60 percent of the wheat and canola sites, and 70 percent of the barley sites indicated some response to applied P when the soil test method was greater than 53 lb/A. This was based on a two bushel yield increase above the control. However, based on a statistical response ($P>0.05$), only 20 percent of wheat sites, 30 percent of barley sites and 15 percent of canola responded to P fertilization at this high soil test level.

We also evaluated the effects of soil pH, organic matter and soil texture on the various extraction methods. In some cases there was a clear separation of responsive sites for acidic, neutral and alkaline soils, particularly for the Miller-Axley P test. Soil pH was not a factor for the Kelowna or modified Kelowna methods. Characterizing the data by soil texture and organic matter had slight effect, but not as great as that found for pH.

This calibration study enabled us to revise the P fertilizer recommendation for the province based on: major soil zone (i.e. Brown, Dark Brown, Thin Black, Black, Gray Wooded and Irrigated), soil texture (medium to fine and coarse), pH (acidic, neutral and alkaline) and seedbed moisture at the time of planting (dry, moist and wet). **Table 2** gives an example of the P recommendations for wheat grown in the Brown and Black soil zones based on the Kelowna P method.

Characterizing these new recommendations by soil zone, pH, texture and seedbed moisture helps make them applicable to Saskatchewan, Manitoba and other areas of the Northern Great Plains with similar type soils. More detailed tables have been provided to soil test laboratories working in the region which include recommendations for each P soil test method. BC

Dr. McKenzie is a Research Scientist with Alberta Agriculture, Lethbridge, Alberta. Mr. Kryzanowski is Soil Fertility Specialist with Alberta Agriculture, Edmonton, Alberta.

Foliar Potassium on Cotton – A Profitable Supplement to Broadcast Potassium Application on Low Testing Soils

By R.K. Roberts, D.C. Gerloff and D.D. Howard

Supplementing soil applied K with foliar applied K can increase cotton lint yields for fast-fruiting cotton cultivars. Our research shows that foliar K can be profitable on a low extractable K soil for at least two years even when relatively high rates of K (as high as 120 lb K_2O/A) are soil applied each year.

Foliar applied potassium (K) for cotton was profitable in Tennessee studies on low K soil with fast-fruiting, high yielding cultivars. However, the benefits with foliar K did not continue after high rates of soil applied K built up soil test levels over a period of two years. Tests included conventional and no-tillage.

Procedures

Field experiments were conducted from 1991 through 1994 on a Memphis silt loam soil at the Ames Plantation Experiment Station of the University of Tennessee. Conventional and no-tillage, non-irrigated systems were evaluated. Initial extractable K levels in the 0-6 inch soil layer were 90 and 80 lb/A (low) for conventional and no-tillage, respectively. The cultivar "D&PL 50" was planted in 40-inch rows by mid-May. Potassium chloride (KCl) rates of 0, 30, 60, and 120 lb K_20/A were soil applied to the same plots each year. In addition, foliar fertilization provided 40 lb/A potassium nitrate (KNO_3) in four applications of 10 lb/A, starting at or shortly after bloom and applied on a 9- to 14-day interval. Similarly, the foliar calcium nitrate [$Ca(NO_3)_2$] treatment provided 36 lb/A $Ca(NO_3)_2$ in four applications of 9 lb/A, applied at a rate equal to nitrogen (N) in the foliar KNO_3 treatment (5.6 lb N/A). All foliar treatments were applied in 10 gal/A of water without a surfactant. The check received soil applied K only. All plots received 80 lb/A of N as ammonium nitrate and 60 lb/A of P_2O_5 as triple superphosphate each year. Pix (8 oz/A) was applied in mid-July each year. Conventional tillage plots were planted on fresh beds in 1991 and on stale beds the other years. No-tillage plots were planted on flat seedbeds. Cultural practices observed in the area were used.

Yield response models developed from regression were used to estimate yield gains/A from the foliar treatments compared with the check for five levels of soil applied K (0, 30, 60, 90, and 120 lb K_2O/A) each year. The net revenue gain/A for each level of soil applied K was calculated by subtracting the cost of the fertilizer and its foliar application from the total revenue gain/A. The total revenue gain/A was estimated by multiplying the Tennessee average cotton lint price for 1985 to 1994 by the yield gain/A resulting from foliar KNO_3 predicted from the yield response models. The cost of KNO_3/A was calculated by multiplying the 1994 26¢/lb price of KNO_3 by 40 lb of KNO_3/A. Machinery cost/A to foliar apply KNO_3 was estimated

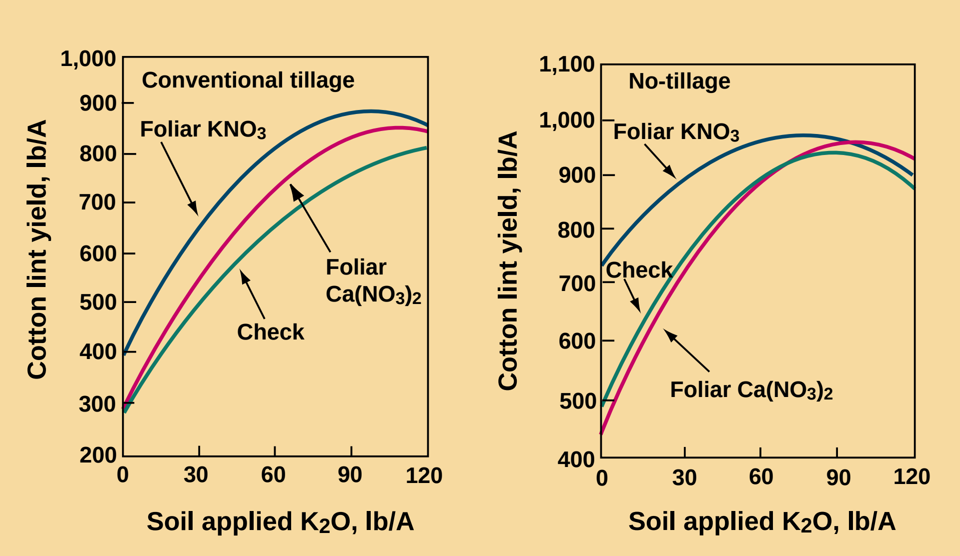


FIGURE 1. Conventional and no-tillage cotton lint yield response models, 1994.

as the sum of fuel, oil, repair, depreciation, insurance, storage, and interest costs for a 90-horsepower, self-propelled sprayer with a 60-ft. boom, \$50,000 purchase price, 15-year useful life, and the ability to cover an acre in 1.7 minutes. Operator labor was valued at \$5.25/ hour and labor hours were assumed to be 1.25 times machine hours. Net revenue gains/A for foliar $Ca(NO_3)_2$ were determined in the same manner, except the 1994 price and amount of $Ca(NO_3)_2$ applied were 25¢/lb and 36 lb/A of $Ca(NO_3)_2$, respectively. Break-even levels of soil applied K that equate net revenue gains/A from foliar KNO_3 with the cost of KNO_3 and its foliar application were calculated.

Results

Machinery and labor costs/A for foliar KNO_3 and $Ca(NO_3)_2$ application were estimated to be about \$9/A. Adding this cost to the costs of KNO_3 and $Ca(NO_3)_2$ gave costs of fertilizers and application of

TABLE 1. Estimated net revenue gains/A from foliar KNO_3 and $Ca(NO_3)_2$ treatments compared to the check, non-irrigated, conventional tillage cotton, 1991 to 1994.

	Net revenue gained (\$/A) from foliar application at various soil applied K rates[1]				
	K_2O, lb/A				
Year, foliar treatment	0	30	60	90	120
1991					
KNO_3	-3	27	41	39	21
$Ca(NO_3)_2$	-15	-8	-6	-9	-17
1992					
KNO_3	21	18	14	8	2
$Ca(NO_3)_2$	-4	-23	-31	-29	-16
1993					
KNO_3	15	13	3	-14	-39
$Ca(NO_3)_2$	-51	-33	-22	-18	-21
1994					
KNO_3	40	76	82	58	6
$Ca(NO_3)_2$	-22	17	34	29	2

[1]Evaluated at the average Tennessee cotton lint price for 1985 through 1994 of \$0.584/lb.

about \$20 and \$18/A for foliar KNO_3 and $Ca(NO_3)_2$, respectively.

Net revenue gains/A from foliar KNO_3 and $Ca(NO_3)_2$ estimated from the yield response models (**Figure 1** for 1994 example) for five levels of soil applied K are presented in **Table 1** for non-irrigated, conventional tillage cotton. Net revenue gains/A from foliar KNO_3 were mostly positive (profitable) except in 1993. Break-even analysis for that year suggested foliar KNO_3 was profitable for lower levels of soil applied K, but unprofitable for soil applied levels greater than 66 lb/A. Relatively low rainfall in 1993, which reduced yields, may have been responsible for the lack of yield response to foliar KNO_3 at the higher soil applied levels because lower yields are not as K-demanding as higher yields. Positive net revenue gains/A for 1994 suggest that foliar KNO_3 on this non-irrigated, conventional tillage cotton, produced on a low K soil, may be profitable when soil applied K rates are high, depending on the weather. Net revenue gains/A from foliar $Ca(NO_3)_2$ were negative except for 1994 when they were mostly positive. Nevertheless, for that year, net revenue gains/A from foliar KNO_3 were about twice as large as from foliar $Ca(NO_3)_2$, suggesting the increased revenue from foliar KNO_3 resulted mostly from K, although some increased revenue could have come from N.

Net revenue gains/A from foliar KNO_3 and $Ca(NO_3)_2$ estimated from the yield response models (**Figure 1** for 1994 example) for non-irrigated, no-tillage cotton are presented in **Table 2**. They were positive for foliar KNO_3 in 1991 and 1992, but the effects of extractable K accumulations in the soil became evident in 1993 and 1994. In those years, net revenue gains/A from foliar KNO_3 became negative with the higher soil applied K rates. In both 1993 and 1994, the break-even rate was 76 lb K_2O/A. These findings suggest that foliar KNO_3 may not profitably supplement soil applied K for more than two years when high (120 lb K_2O/A) levels of K are being applied to a soil initially testing low in K. Net revenue gains/A from foliar $Ca(NO_3)_2$ were negative in 1991 and 1994, but were positive for some levels of soil applied K for 1992 and 1993. These results suggest N might have been important in increasing lint yields for some rates of soil applied K in those years.

Conclusions

Economic analysis suggests that foliar KNO_3 on this loess-derived, low K soil in western Tennessee provides higher

TABLE 2. Estimated net revenue gains/A from foliar KNO_3 and $Ca(NO_3)_2$ treatments compared to the check, non-irrigated, no-tillage cotton, 1991 to 1994.

Year, foliar treatment	Net revenue gained (\$/A) from foliar application at various soil applied K rates[1] — K_2O, lb/A: 0	30	60	90	120
1991					
KNO_3	16	35	46	49	43
$Ca(NO_3)_2$	-17	-15	-17	-22	-31
1992					
KNO_3	46	27	18	20	33
$Ca(NO_3)_2$	-22	5	20	20	7
1993					
KNO_3	66	31	7	-6	-9
$Ca(NO_3)_2$	-35	-11	6	17	21
1994					
KNO_3	123	66	20	-14	-36
$Ca(NO_3)_2$	-52	-29	-20	-27	-48

[1]Evaluated at the average Tennessee cotton lint price for 1985 through 1994 of \$0.584/lb.

net revenues/A than not applying it to cotton, even when relatively high rates of K are applied to the soil for up to two years. However, high K rates for three or more years may substantially reduce the profitability of foliar KNO_3. Alternatively stated, K deficiencies that can be corrected by foliar KNO_3 may be eliminated after about two years of high soil applied K rates. This finding is more certain for no-tillage than conventional tillage cotton. The conventional tillage cotton produced negative net revenue gains/A from foliar KNO_3 for high soil applied K rates in 1993, but net revenue gains/A were positive for all K rates in 1994. However, no-tillage cotton had negative net revenue gains/A for high K rates in both 1993 and 1994.

Cotton lint yields were generally unresponsive to foliar $Ca(NO_3)_2$. These results suggest that lint yields responded to the K in foliar KNO_3 rather than the N. Exceptions were 1994 conventional tillage cotton and no-tillage in 1992 and 1993, when yields appeared to be somewhat responsive to foliar N. Earlier research has shown that other K sources may also result in responses, provided spray solutions are buffered to pH levels between 4 and 6. BC

Dr. Roberts is Professor of Agricultural Economics, University of Tennessee. Dr. Gerloff is with the Department of Agricultural Economics and Resource Development, University of Tennessee. Dr. Howard is Professor, West Tennessee Experiment Station, Jackson, TN 38305.

Information Agriculture Conference Scheduled for August 6-8, 1997

Dates for the 1997 Information Agriculture Conference are now set for Wednesday, August 6 through Friday, August 8, at the Krannert Center for the Performing Arts, University of Illinois, Urbana-Champaign. Plans were announced by Dr. David W. Dibb, President of the Potash & Phosphate Institute (PPI).

"This will be the third Information Agriculture Conference, following highly successful events in 1995 and 1996," he noted. "The program content and focus continues on precision farming, with site-specific management of nutrients and other crop inputs emphasized even more this year."

The Conference brings together a unique cross section of farmers, industry representatives, university and Extension specialists, consultants and others interested in new technology, equipment, and information for more efficient crop production.

The program this year will include workshop sessions analyzing real case studies of farms using site-specific systems. Analytical and mapping software will be demonstrated.

An exhibit area will include displays by a wide variety of companies and organizations offering products and services related to the program topics.

Registration fee for the 1997 Information Agriculture Conference is $250 per individual before July 8 and $350 after that date. Student registration fee is $100. Exhibitor fee is $300 for a standard booth area.

Additional details will be available on the Information Agriculture Home Page on the Internet at:
http://w3.ag.uiuc.edu/INFOAG/
and on the PPI Home Page at:
http://www.agriculture.com/contents/ppi/.
For conference registration,
call **(202) 675-8250** or fax **(202) 544-8123**. BC

PRICE IS THE KEY TO PRODUCTION

IS IT REALLY GOING TO HAPPEN THIS TIME? After all these years of wrong predictions? Is food scarcity on a world wide level inevitable?

MALTHUS STARTED THE STORY—MANY YEARS AGO. It has been revived periodically...in books such as *The Hungry Planet*, *The Population Bomb*, and *Famine 1975*. These concerns led the USDA to urge farmers to plant "from fence row to fence row." They did, and surplus production plagued us.

IS IT DIFFERENT THIS TIME? Farm price supports are phasing out. A new era is forecast. Grain had to be pulled from accumulated stocks to satisfy 1995 food demands. To meet the same world needs this year, farmers must grow an additional 60 million tons of grain, and to feed the 100 million people born in the last year will require 25 million tons.

CAN WE MEET SUCH NEEDS IN THE YEARS AHEAD? Of course we can. Precision farming, sustainable agriculture, and conservation practices all have their place, but the answer ultimately lies in production and price. The price of wheat, relative to wages in the U.S., is only about one-twentieth of its level two centuries ago.

SHOULD FOOD BECOME TOP PRIORITY, PRODUCTION POTENTIAL IS BEYOND IMAGINATION. With modern technology and attractive prices, farmers and agricultural scientists can meet any production challenge...and still conserve our resources.

J. Fielding Reed

BETTER CROPS
WITH PLANT FOOD

Potash & Phosphate Institute
Suite 110, 655 Engineering Drive
Norcross, Georgia 30092-2837

Periodicals
Postage