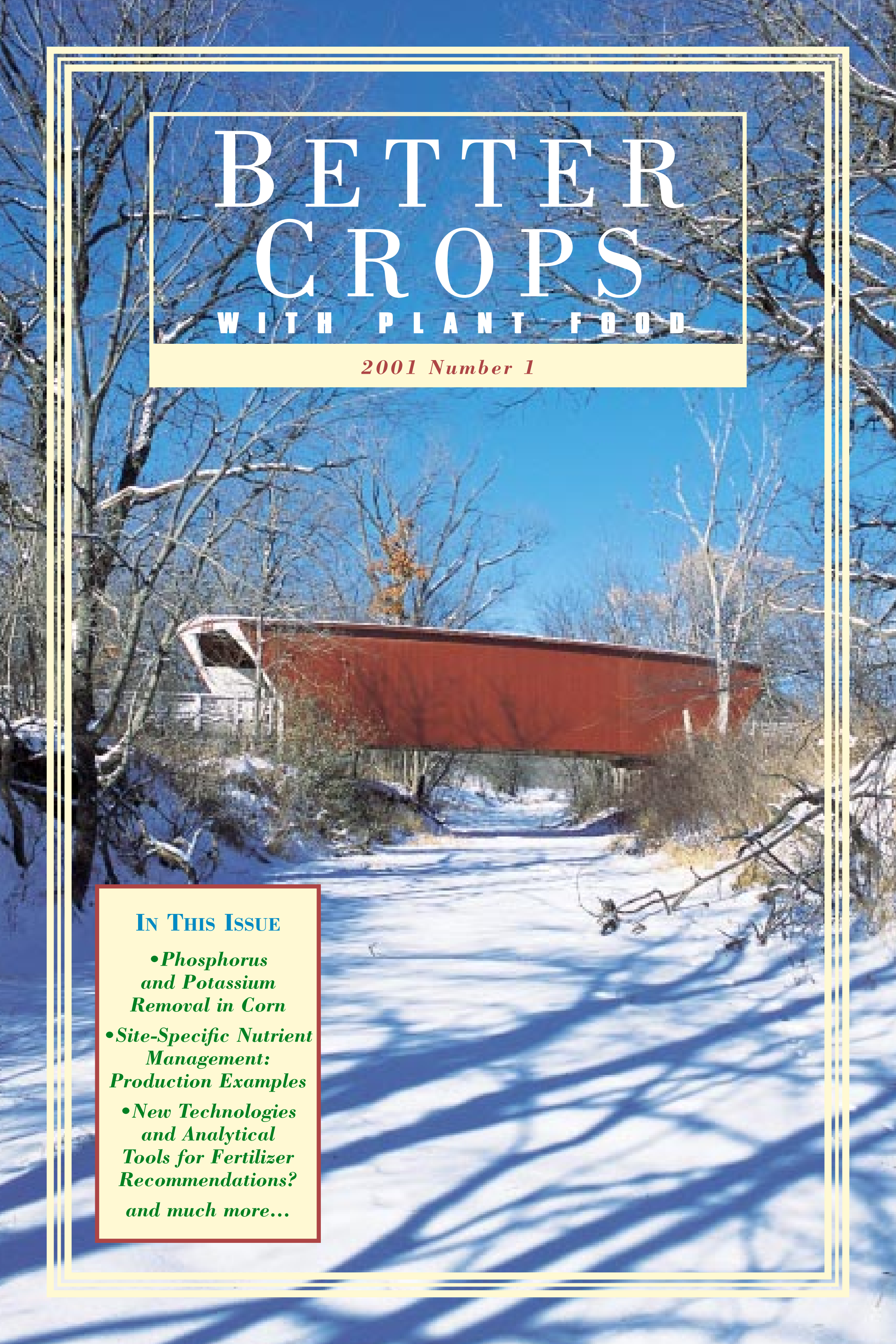
BETTER CROPS
WITH PLANT FOOD

2001 Number 1



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BETTER CROPS
WITH PLANT FOOD

Vol. LXXXV (85) 2001, No. 1

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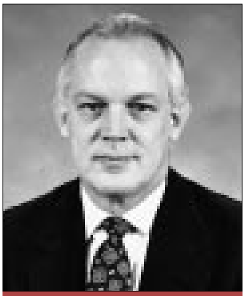
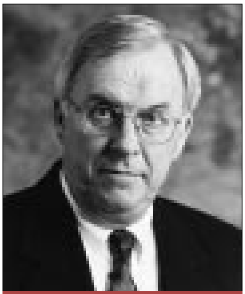
C. Steve Hoffman Elected Chairman, Henk Mathot Vice Chairman of PPI and FAR Boards of Directors

C. Steve Hoffman, President, IMC International and Senior Vice President of IMC Global Inc., 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. **Henk Mathot**, President of Worldwide Fertilizer Operations, Cargill, was elected Vice Chairman of the PPI and FAR Boards.


C. Steve Hoffman

"These leaders bring a wealth of experience, in North America and worldwide, to these important leadership positions for the Institute in the year ahead," said Dr. David W. Dibb, President of PPI. "We look forward to further progress in PPI programs with their guidance."

Mr. Hoffman is an officer of IMC Global, headquartered in Lake Forest, Illinois. He is responsible for the Company's international phosphate and potash marketing and sales activities, as well as overseas business development. He joined the Company in 1974, was named Director/Asia Pacific, then promoted to Senior Vice President, Sales/Marketing, in 1987. He became Senior Vice President, Wholesale Marketing, in 1990 and was promoted to Senior Vice President Sales/Marketing in 1992. He moved to the position of Senior Vice President, International, IMC Global Inc., in 1994. Mr. Hoffman is President and a Director of the Phosphate Chemicals Export Association (PhosChem). He serves on the Board of Directors for the Canadian Potash Export Association (Canpotex) and the Sulphate of Potash Information Board.


Henk Mathot

As President of Worldwide Fertilizer Operations, Mr. Mathot's responsibilities with Cargill include phosphate mining and fertilizer production facilities in Florida and the company's North American and international network of fertilizer trading, blending, and distribution facilities. He also serves on the board of Saskferco, Cargill's nitrogen-producing joint venture with the Province of Saskatchewan. He joined Cargill in 1974 as production manager at its protein-products plant in Amsterdam, The Netherlands. He was later appointed general manager of the corn milling plant in Tilbury, England, and then technical director for Cargill Europe. In 1986, he was appointed president of Cargill's Florida-based phosphate fertilizer operations, before becoming president in 1994 of Cargill Agricola S.A., the Brazilian subsidiary of Cargill.

In other action of the PPI Board, Stanley A. Riemann of Farmland, Inc. was elected Chairman of the Finance Committee. Intrepid Mining, LLC/Moab Potash was approved as a new member of the Institute. New members of the PPI Board of Directors include: David Delaney, President, PCS Sales; Michael M. Wilson, Executive Vice President and COO, Agrium Inc.; Robert P. Jornayvaz, III, Owner/Manager, and Hugh E. Harvey, Jr., Owner/Manager, Intrepid Mining, LLC/Moab Potash.

Three individuals were elected as Honorary Lifetime Members (Emeritus) of the PPI Board. They are Charles E. Childers, Potash Corporation of Saskatchewan Inc.; John U. Huber of IMC Global Inc.; and William J. Robertson of Agrium Inc.

During the FAR Board of Directors meeting, Barry Jarrett, Vice President of Sales, Cypress Chemical Co., was elected to the Board. Terry L. Roberts, Vice President, PPIC Latin America Programs, continues as President of FAR. BC

EASTERN U.S.

Phosphorus and Potassium Removal in Corn

By J.R. Heckman, J.T. Sims, D.B. Beegle, F.J. Coale, S.J. Herbert, and T.W. Bruulsema

State mandates for nutrient management planning have prompted a need to re-evaluate established crop nutrient removal values for corn. Where application rates of manure are restricted to the level of crop nutrient removal, land requirements for livestock operations vary with crop nutrient content. This study measured the variability of P and K removal by corn grain produced in the eastern U.S.

> An accurate accounting of crop removal of phosphorus (P) and potassium (K) is an important component of a nutrient management plan. Recent measurements of removal indicate that P and K contents of harvested grain corn vary considerably across sites and growing conditions, with some tendency to increase with soil fertility level and yield.

We grew corn in five states (Delaware, Massachusetts, Maryland, New Jersey, and Pennsylvania) in 1998 and 1999 for a total of 23 site-years. Sites were selected to represent the wide range of soils and P fertility levels on farm fields within the region. They included both on-farm and research station land. Local extension recommendations guided cultural practices. Starter fertilizer at all sites supplied 30 lb P_2O_5/A in the form of mono-ammonium phosphate. We measured yields from a harvested area of two 20-foot rows in each of four replicate plots. Harris Laboratories in Lincoln, Nebraska, analyzed all grain samples for P and K concentration. All nutrient content values are expressed on a 15.5 percent moisture content basis.

Minimum and maximum nutrient contents for P and K across all sites varied by more than two-fold for P and by almost two-fold for K (**Table 1**). Since sites differed in soil and weather conditions as well as hybrids, it is not possible to isolate the effect of hybrid completely. However, one hybrid grown at six of the sites showed almost as much variation in P and K contents as the 10 hybrids across all 23 sites. The mean values we obtained for corn grain P and K removal agree fairly well with those found in published nutrient removal tables (**Table 2**).

Some of the variability in grain P content appeared to be associated with soil test P (**Figure 1**). The Mehlich 3 P (M3P) soil test ranged from 36 to 418 parts per million (ppm) across the 23 sites, with a mean of 138 ppm. Since the agronomic optimum range is about 30 to 50 ppm, most of these soils were high in P. Soil test P correlated positively with grain P content ($r = 0.52$; $p < 0.02$). However, for any given soil test level, there was still considerable variability in grain P content. Since K fertilizer application varied from site to site, we could not properly evaluate whether a

TABLE 1. Variation in nutrient content of corn grain in 1998

	All hybrids (23 sites)		Pioneer 3394 (6 sites)	
	P_2O_5	K_2O	P_2O_5	K_2O
	lb/bu			
Mean	0.43	0.27	0.37	0.24
Minimum	0.24	0.18	0.24	0.18
Maximum	0.58	0.35	0.44	0.28
CV, %[1]	20	14	19	15

[1] CV = coefficient of variation, standard deviation expressed as percentage of the mean.

TABLE 2. Published reference values for

Source	P_2O_5	K_2O
	.... lb/bu	....
Potash & Phosphate Institute	0.44	0.29
North Carolina State University	0.35	0.27
Penn State University	0.40	0.30
USDA-NRCS	0.34	0.20

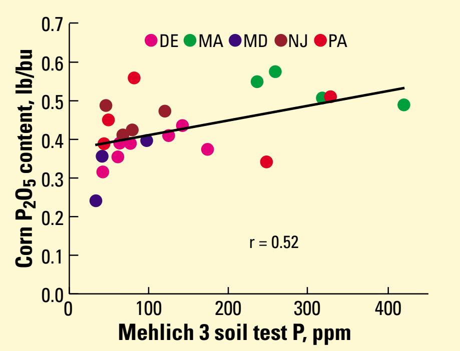


Figure 1. Association between grain P (P_2O_5) content of corn and soil test P level at 23 sites in five states.

similar relationship existed between soil test K and grain K.

Both grain P and K contents were also positively associated with yield (**Figures 2** and **3**). Since yields reflect the favorability of the growing environment, it is possible that sites with more favorable conditions for corn growth also had better conditions for the diffusion of P and K from the soil to the roots. The correlation coefficients between grain P and K content and yield (r = 0.38 and 0.36, respectively), though statistically significant at the 10 percent level of probability, were not strong.

Much of the variability in grain P content was not explained even by a combination of the associations with soil test P and yield. Grain P content could be expressed as a function of both yield and M3P as follows: $P = 0.31 + 0.00040(Y) + 0.00034(M3P)$; $R^2 = 0.33$, where P = grain P_2O_5 (lb/bu), Y = grain yield (bu/A), and M3P = Mehlich 3 P in soil (ppm). Within this two-variable equation, statistical significance for the Y coefficient was only at the 20 percent level of probability while that for M3P was at the 3 percent level. Our observations do not support interpretation of this equation as proof of a cause-and-effect relationship.

Rather, the equation describes the mean grain P_2O_5 content as a function of weak trends with soil test P and yield observed within the five states. The R-square value of 0.33 indicates that it explained only one-third of the variability observed. In other words, this equation does not estimate nutrient removal much better than the mean value of 0.43 lb/bu. Neither the mean value nor the regression should be extrapolated to soil test and yield levels beyond the range encountered in our sites, nor should they be used in other regions without verification by local data.

Some of the remaining variability in grain P and K contents may have been related to the soils at each of the sites (**Table 3**). Specific effects of soil characteristics could not be separated from the differences in weather

(continued on page 6)

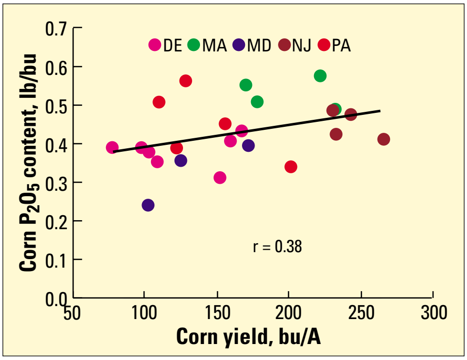


Figure 2. Association between yield and grain P (P_2O_5) content of corn.

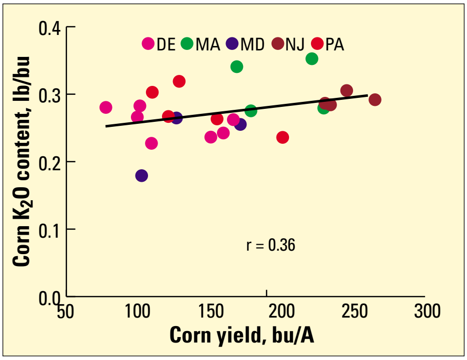


Figure 3. Association between yield and grain K (K_2O) content of corn.

Information Agriculture Conference Set for August 7-9, 2001

The popular Information Agriculture Conference series continues with InfoAg 2001 scheduled for August 7, 8 and 9. Organized by PPI and FAR, InfoAg 2001 will take place at the Adam's Mark Hotel – Airport, Indianapolis, Indiana.

Dr. Harold F. Reetz, Jr., PPI Midwest Director, will serve as conference planning coordinator. Program tracks will be offered in four major components: Economics/Farm Management; Data Analysis/Tools; Site-Specific Nutrient Management; and Communications/Environment. As with previous Information Agriculture Conferences, an exhibit area will feature some of the latest in site-specific systems, data management, and communications technology. There will also be a return of the special Cyber-Dealer sessions targeting the business aspects of incorporating site-specific management systems services into retail supply and consulting businesses.

Individual registration fee for InfoAg 2001 is $350.00 until July 15 and $450 thereafter.

More information and details are available by phone at (605) 692-6280, by fax at (605) 697-7149, or the website at **www.ppi-far.org/infoag**. BC

Phosphorus and Potassium Removal...(continued from page 5)

conditions excountered at each site. The overall differences between the two years were very small.

Variability in nutrient content implies that some farmers may need to obtain an analysis of their harvested crop in order to accurately assess nutrient removal. Nutrient management planners may consider taking into account increased crop removal of P at higher soil test levels and at higher yield levels. Livestock producers should also consider the implications of variability in P and K content of grain upon ration balancing for the mineral nutrition of their animals. BC

TABLE 3. Soils included in the five-state

State	Soil
DE	Evesboro loamy sand
DE	Kenansville sandy loam
DE	Matapeake silt loam
DE	Rumford loamy sand
DE	Sassafrass sandy loam
MA	Hadley very fine sandy loam
MA	Merimac sandy loam
MD	Mattapex silt loam
NJ	Aura gravelly sandy loam
NJ	Freehold sandy loam
NJ	Quakertown silt loam
PA	Allenwood silty clay loam
PA	Braceville gravelly loam
PA	Hublersburg silty clay loam
PA	Linden sandy loam

Dr. Heckman is with Rutgers University, New Jersey. Dr. Sims is with University of Delaware. Dr. Beegle is with Pennsylvania State University. Dr. Coale is with University of Maryland. Dr. Herbert is with University of Massachusetts Cooperative Extension. Dr. Bruulsema is Eastern Canada and Northeastern U.S. Director, PPI, located in Guelph, Ontario. E-mail: tbruulsema@ppi-far.org

CALIFORNIA

Correcting Potassium Deficiency Can Reduce Rice Stem Diseases

By Jack Williams and Sara Goldman Smith

Research in the Sacramento Valley of California shows that potassium (K) fertilization of soils deficient in available K will not only increase rice yields, but may also reduce pressure from such diseases as stem rot and aggregate sheath spot (AgSS).

Mineral nutrition is a key management tool for maximizing yield and promoting good market quality of rice. In California's Sacramento Valley, home to about 95 percent of the state's rice production, fertilizer nitrogen (N) and phosphorus (P) are nearly universally applied each year, averaging 140 lb N/A and 45 lb P_2O_5/A. Potassium fertilizer, however, is less generally used. Soils along the eastern slope of the valley frequently have low available K, in the range of 20 to 80 parts per million (ppm) ammonium acetate extractable. These shallow, coarse textured, hardpan or claypan soils were formed on alluvial fan terraces and are continuously cropped to rice, with many fields producing 30 or more consecutive crops. Cropping removes about 35 or 40 lb K/A/yr (42 to 48 lb K_2O equivalent) in the grain, slowly reducing the available soil supply. In recent years, response to K application in trials has become more common, and many growers in the area have begun to apply K annually, at rates of 60 to 120 lb K_2O/A. Straw removal from these low K soils, necessary because of reduced burning, will likely increase in the next few years, which will accelerate the rate of K removal.


Late season K deficiency symptoms on foliage of rice in California.

Important rice diseases in California include stem rot (*Sclerotium oryzae*) and AgSS. (*Rhizoctonia oryzae-sativae*). Either or both may appear in virtually any field.

Several researchers have confirmed in many previous studies that stem rot increases at higher N rates, and AgSS either decreases or does not respond to N. However, since California rice fields have not historically had widespread K deficiency, we have not studied the effect of K on rice diseases until recently. Occasionally, we have observed K-deficient rice fields that also have had very high disease levels, particularly stem rot. Interaction of K deficiency and disease has been reported elsewhere, but never in California. In addition, new rice residue management practices, including rice straw removal, make it important to increase our understanding of how K nutrition interacts with rice diseases.

Field Study

In 1996, we established a N x K interaction study in a rice field that had a history of very high disease and low yield. We suspected K deficiency was part of the problem because soil samples from the final seedbed in 1996 tested 23 ppm exchangeable K. The established critical K value for California rice is 60 ppm. The trial compared two rates of N and six K treatments. The K treatments, consisting of rates and timing of potassium chloride (KCl), were superimposed over the N rates in a split plot design with four replications. We evaluated leaf N and K at 45 and 63 days after planting (DAP), rated diseases at 114 DAP, and measured height, lodging and yield. Since there were no appreciable interactions between N and K in most cases, the results for N are averaged across K treatments and those for K across N treatments.

Results

At 45 DAP, we saw plant growth effects typical of K deficiency in the low K treatments, including reduced height, tillering and leafiness. Lower leaves had brown spots on the upper portion of the leaf blade and occasional leaf tip necrosis. Leaf samples taken at 45 and 63 DAP showed K percent increasing with rates and decreasing with time with several treatments falling below established critical values (**Figure 1**). Therefore, we expected a yield response in some of these treatments. There was no effect of increased N on leaf K concentration at 45 DAP. At 63 DAP, leaves from the lower N plots had a slightly higher K concentration (data not shown).

Increasing K rates decreased stem rot incidence and AgSS severity **(Table 1).** Stem rot severity and incidence increased with higher N, while AgSS incidence decreased marginally. There was also significant interaction of N and K for incidence of stem rot which tended to be higher at high N and low K (data not shown). Percent K in leaf blades at 63 DAP correlated negatively with severity for both diseases (**Figure 2**). In other words, higher leaf K was associated with lower disease incidence.

Increasing K rates resulted in increased plant height, delayed maturity (measured as higher moisture content at harvest), and more yield (**Table 2**). While K did increase plant height, lodging was not correspondingly increased. The effect of K on lodging appeared to be related to timing, rather than rate at which delayed K application resulted in increased lodging. Estimated maximum yield with preplant K rates occurred between 120 and 180 lb K_2O/A. Topdressing 120 lb K_2O/A at 45 DAP appeared to increase yield slightly over the same rate applied preplant, although the difference was not statistically significant.

The higher N rate increased plant height and lodging, delayed maturity, and decreased yield (**Table 2**). This suggests that the grower's N program (lower N rate) was near optimum.

Summary

Potassium deficiency can contribute to stem diseases of rice.

This field research confirmed what we had speculated – that stem diseases of rice may be more severe in K-deficient soils. While correcting the deficiency did not eliminate the diseases, they were generally less damaging when K was adequately supplied. This is the first such confirmed report for rice in

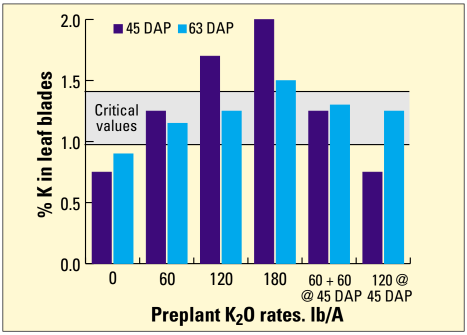


Figure 1. Percent K in leaf blades at 45 and 63 days after planting, at different levels and timing of KCl fertilizer, averaged across N treatments.

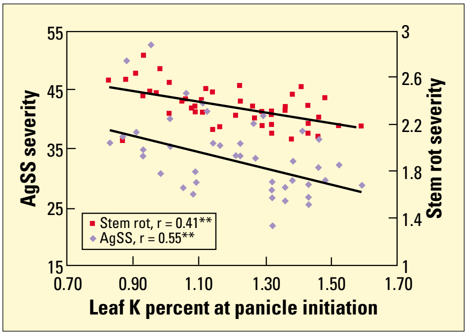


Figure 2. Correlation of leaf K percent at 63 days after planting (approximately panicle initiation growth stage) to stem rot and AgSS severity ratings. (**regression is significant at the 99 percent probability level).

California. The combination of high N and low K was particularly important in enhancing stem rot incidence; hence, a balance of N and K is an important consideration when managing rice fields with high disease potential and low K.

TABLE 1. Effect of N and K treatments on disease severity and incidence.

N treatments[1]	Stem rot severity, 1-5[3]	Stem rot incidence, %	AgSS severity, %	AgSS incidence, %
Low N	1.75	35.5	41.5	96.5
High N	2.06	45.0	42.9	94.2
Significance, %	>99.9	>99.0	ns	>95.0
K treatments, lb K_2O/A				
0	2.0	50.3	45.2	95.0
60 preplant	2.0	43.9	42.8	94.9
120 preplant	1.8	38.6	41.1	96.8
180 preplant	1.9	39.3	40.5	96.5
60 + 60[2]	1.8	33.6	40.7	94.3
120 @ 45 DAP	1.9	35.9	42.8	94.8
$LSD_{0.5}$	ns	12.0	3.2	ns

[1] Low = grower rate of 147 lb N/A. High = grower rate + 40 lb N/A.
[2] 60 lb preplant + 60 lb 45 days after planting.
[3] Higher number indicates increased stem rot severity.

Potassium is a fertilizer, not a fungicide.

The research also suggests that K had a significant role in both plant nutrition and the course of disease on this K-deficient soil. However, it is important to recognize that the role of K fertilization is primarily plant nutrition, not disease prevention. To confirm this, we did follow-up work in 1997. We established K and zero K sites in 10 rice fields that represented a diversity of rice soils in the Sacramento Valley. None of these soils were deficient in K, averaging 189 ppm over a range of 82 to 246 ppm. Application of 120 lb K_2O/A as KCl did not affect yield, leaf K, or N percent at any of three sample dates. In addition, stem rot and AgSS...incidence or severity... were not affected by the addition of K fertilizer. Clearly, K must first be deficient before effects of K application on yield and disease can be expected.

TABLE 2. Effect of N and K treatments on lodging, height, grain moisture, and grain yield.

N treatments[1]	Lodging, %	Height, inches	Grain moisture, %	Yield, lb/A
Low N	12.5	37.3	21.3	8,068
High N	51.9	38.3	21.9	7,673
Significance, %	>99.9	>99.9	>99.0	>99.0
K treatments, lb K_2O/A				
0	31.3	35.2	21.0	7,155
60 preplant	30.0	37.5	21.2	7,725
120 preplant	30.0	39.0	21.9	7,803
180 preplant	26.3	39.2	22.0	8,292
60 + 60[2]	43.8	38.3	21.9	8,039
120 @ 45 DAP	31.9	37.2	21.6	8,208
$LSD_{0.05}$	15.2	0.9	0.6	423

[1] Low = grower rate of 147 lb N/A. High = grower rate + 40 lb N/A.
[2] 60 lb preplant + 60 lb 45 days after planting.

Rice straw removal will induce K deficiency on some soils.

The role of K in rice crop nutrition in California may change in the near future as rice straw management practices change. When rice residue is burned, the historical practice, 93 to 98 percent of the K in the residue is returned to the soil in the ash. Currently, growers are soil-incorporating most of their rice straw as new regulations phase down burning. This practice also returns essentially 100 percent of the mineral nutrients to the soil. Straw removal, however, would greatly increase the amount of K exported from these soils.

Mr. Williams is Farm Advisor-Rice, Field Crops, and Soils, Sutter/Yuba Counties, University of California Cooperative Extension. Ms. Goldman-Smith is Post Graduate Researcher, University of California, Davis.

Translocation of Surface-Applied Phosphorus and Potassium into a Grassland Soil

By S.S. Malhi, J.T. Harapiak, R. Karamanos, and K.S. Gill

Tame forage crops for grazing and hay production occupy over 11 million acres in western Canada. While much of this area receives little management attention once established, numerous research trials have shown that forage productivity can be enhanced significantly through fertilizer application. Fertilizers are generally applied to established forage stands by broadcast application on the soil surface.

Because both P and K are considered relatively immobile in soil and only a small portion of the fertilizer P and K is used by the plants in the year of application, the accumulation of these nutrients and their gradual downward movement have been observed as a result of fertilization. A review of the published scientific literature suggests that the amount and translocation depth of surface-broadcast P and K into the soil vary from one study to another. Understanding the long-term movement of P and K into different soil depths resulting from their surface applications would assist in helping to clarify any potential for surface and groundwater contamination. The objective of this study was to determine the effects of long-term use of different nitrogen (N), P and K fertilization rates on soil pH and extractable P and K concentrations in a grassland soil profile.

The absence of phosphorus (P) or potassium (K) accumulation below the 12-inch depth suggests that there is very little potential for deep leaching from application of P or K fertilizer to forage stands in most regions of western Canada.

The field experiment was located on a Thin Black loam soil (Typic Boroll) with 9.5 percent organic matter and a pH of 6.8, in an area with a mean annual precipitation of about 18 inches and a growing season from early-May to late-September. A smooth bromegrass (*Bromus inermis* Leyss) stand, harvested for hay each year in late July, received various combinations of N, P and K fertilizer rates. The annual fertilization rates were 0, 75, 150, 250, and 300 lb N/A (as ammonium nitrate) for 30 years (1968 to 1997), in selected combinations with 0, 34, 68, 114, 136, 227, and 272 lb P_2O_5/A (as triple superphosphate) for 10 years (1968 to 1977), and with 0 and 48 lb K_2O/A (as potassium chloride) for 14 years (1984 to 1997). A zero-fertilizer control was also maintained over the 30 years of the study. The fertilizers used were surface broadcast in early spring (mid- to late-April) on the plots arranged in a randomized complete block design with six replicates. In October 1997, soil samples were taken from 0- to 2-in., 2- to 4-in., 4- to 6-in., 6- to 12-in., 12- to 24-in., 24- to 36-in., and 36- to 48-in. depths. The soil pH (1:2 soil:water mixture), P (0.03 M ammonium fluoride + 0.03 M sulfuric acid mixture) and K (1.0 M ammonium acetate) were determined on these soil samples.

Results show that pH decreased with increasing N rate, and the effect of N rate on the soil pH declined with soil depth (**Figure 1**). Only at the highest N rate of 300 lb N/A did soil pH show any change below the 4-inch depth. Extractable P concentration in the soil exhibited the effect of 10 years of P fertilization rates, even though application of P had been terminated in 1977, 20 years prior to soil sampling (**Figure 2**). The P accumulation and translocation depth increased with increasing N and P rates and with a decline in the soil pH. Accumulation in the surface soil depths at high N rates was attributed to N-induced acidification, making soil P more soluble. Most of the P accumulation from surface-applied P fertilizer occurred in the top 4-in. soil layer, and almost no accumulation was recorded below the 12-in. depth.

Surface-applied K prevented N-induced K depletion from the top 36-in. soil layer (**Figure 3**). While only a small accumulation of K was observed in the 4- to 12-in. soil layer, 48 lb K_2O/A per year appears to have achieved a balance between K addition and bromegrass removal of K. The absence of P or K accumulation below the 12-in. depth suggests that there is very little potential for deep leaching of these nutrients. However, where high N rates were combined with P application, P accumulation occurred in the surface soil, and this could increase the potential for P loss in surface water runoff, especially on breaking of the forage stand.

In western Canada, the wide-scale adoption of no-till breaking of forages using herbicides has helped to reduce the amount of tillage required to prepare a seedbed for the next crop in rotation. If herbicide termination of forages were combined with no-till seeding of annual crops, any potential for loss of surface accumulated nutrients could be minimized.

Bromegrass forage yields from this study indicate that the crop responded positively to fertilizer N applications, with minor yield response to K fertilization, and little or no yield response to P additions. As referred to earlier, the solubilization of soil P with fertilizer N additions appears to have met the hay crop requirements. An economic analysis of the N response data revealed that the optimum N rate for bromegrass hay production in this region of Alberta was 100 lb N/A, when evaluated over a broad range of fertilizer costs and hay prices. As a result, farmers fertilizing their hay at or below these economic N rates can expect to have a minor impact on soil pH levels and accumulation of soil P in the surface 0 to 2 inches.

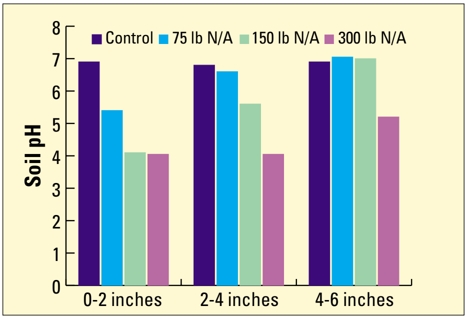


Figure 1. Soil pH as influenced by different rates of N applied for 30 years (no P or K was applied).

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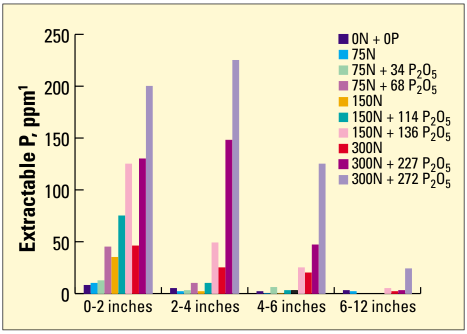

Figure 2. Soil extractable P as influenced by different rates of N applied for 30 years (1968-1997) and P for 10 years (1968-1977).

[1]parts per million

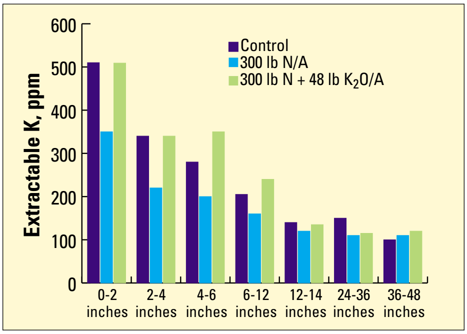

Figure 3. Soil extractable K as influenced by different rates of N applied for 30 years (1968-1997) and K for 14 years (1984-1997).

MIDWEST

Site-Specific Nutrient Management: Production Examples

By H.F. Reetz, Jr., T.S. Murrell, and L.J. Murrell

This article focuses on the usefulness of site-specific approaches in assessing crop requirements for nutrients. Two examples are provided, one from Illinois and one from Indiana.

Illinois grid-sampled example. A 90-acre central Illinois field was sampled on a 1-acre grid. The yield goal for corn was set at 200 bu/A, and the yield goal for soybeans was set at 60 bu/A. After many years of following field-average recommendations for "maintenance plus buildup" according to the University of Illinois Agronomy Handbook, the average potassium (K) soil test at 350 lb K/A required no further buildup application. So the recommendation called for "maintenance-only" on the whole field.

Production agriculture is currently grappling with many issues related to site-specific nutrient management. Some of the more important topics are: obtaining accurate maps of soil test variability; evaluating the appropriateness of current recommendations when applied at smaller scales; and accuracy of variable nutrient applications.

Figure 1 shows the spatial distribution of the soil test results from the 1-acre grid sampling. When the 1-acre grid test results were interpreted for the same yield goals, 47 of the 90 acres showed a need for buildup fertilizer in addition to the maintenance application. Thirty acres required maintenance only (the same as the field-average recommendation), and 13 acres had soil K levels high enough that no fertilizer was required at all. **Two-thirds of the field was not properly assessed by the field-average approach.**

Zone-managed Indiana field. The second example is a 157-acre field in central Indiana. Three-year average corn yields varied by soil type (**Table 1**). Larger soil mapping units were subdivided into areas small enough for representative soil samples to be

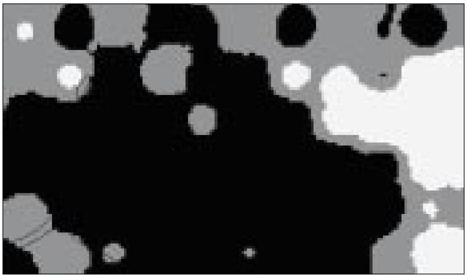

Figure 1. Fertilizer recommendations for 200 bu/A corn and 60 bu/A soybeans on a 90-acre central Illinois field.

Legend: Black areas: maintenance + buildup (47 acres); Gray areas: maintenance only (30 acres); White areas: no fertilizer needed (13 acres)

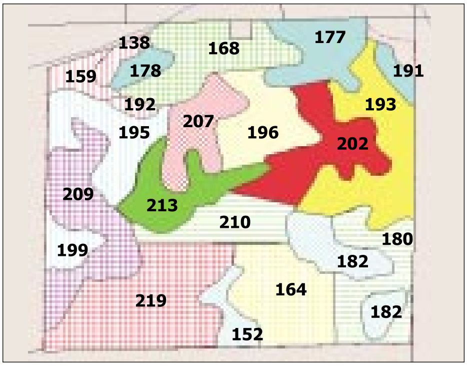

Figure 2. Yield goals for each management zone, determined from three-year averages for a 157-acre central Indiana field.

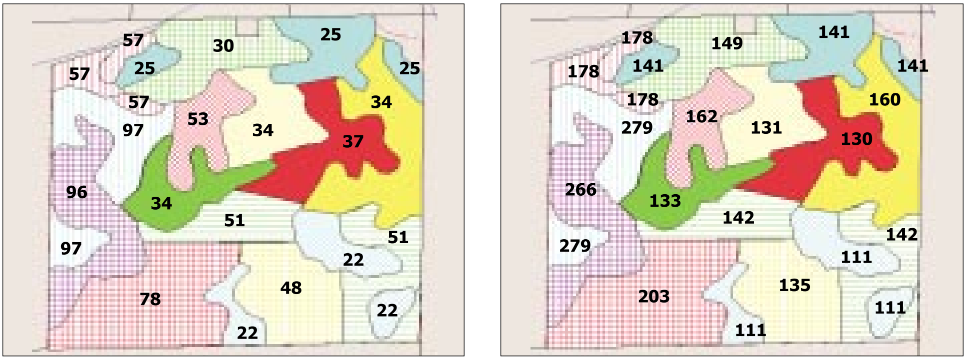

Figure 3. Bray P-1 soil test levels (on left) and Mehlich 3 K soil test levels (on right) for each management zone. Levels are in ppm.

collected. They ranged in size from 1 to 19 acres. All samples were composites of 20 to 30 individual soil cores, each geo-referenced and taken to a depth of 6 inches. These subdivisions in soil mapping units formed the basis for management zones.

Recommendations for phosphorus (P) and K were based on the Tri-State Fertilizer Recommendations (Vitosh, M.L., J.W. Johnson, and D.B Mengel. 1995. Tri-state fertilizer recommendations for corn, soybeans, wheat, and alfalfa. Ext. Bull. E-2567. Purdue Univ. Coop. Ext., Purdue University, West Lafayette, IN). Recommendations were calculated using yield goal, soil test level, cation exchange capacity (CEC), and soil buffer capacity. Three-year average corn grain yields were used as the yield goal for each zone, which ranged from 138 to 213 bu/A (**Figure 2**).

The Bray P-1 and Mehlich 3 K soil tests for each management zone are shown in **Figure 3**. Soil test P and K ranged from 22 to 97 parts per million (ppm) and 111 to 279 ppm, respectively. Field average P and K soil test levels, calculated from zone soil tests using zone area as a weighting factor, were 52 and 170 ppm, respectively.

TABLE 1. Three-year average corn grain yields for a central Indiana field in a

Soil series	Abbreviation	3-yr. ave. grain yield, bu/A
Brookstone sil[1]	Bs	193
Crosby sil	Cs	187
Miami sil	Mi	159
Russell sil	Ru	192
Shoals sil	Sh	138

[1] Si = silt; l = loam

Recommendations based on calculated field average soil test levels would have called

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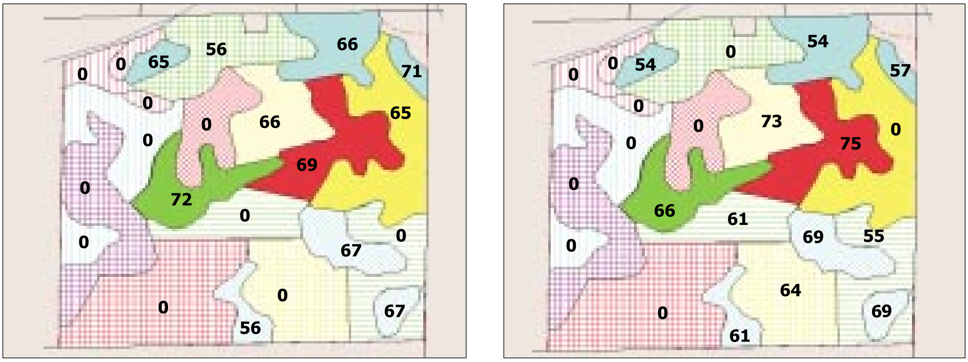

Figure 4. Nutrient recommendations for (on left) P (lb P_2O_5/A) and (on right) K (lb K_2O/A) for each management zone.

Multiple Year Response of Irrigated Winter Wheat to a Single Application of Phosphorus

By Ardell D. Halvorson and Curtis A. Reule

Findings of a multi-year study with a continuous wheat system in the Great Plains indicate that a single phosphorus (P) fertilization can influence grain yields for several years. Therefore, the cost of fertilizer P applications should probably be amortized over several years. The results show that a balanced nitrogen (N) and P fertilization program is needed to optimize yields and economic returns and reduce the potential for nitrate-N (NO_3-N) contamination of groundwater.

Soil P deficiency for winter wheat and other crops is common in the central Great Plains. Continued years of cropping with very little fertilizer P being applied to crops have increased the frequency and severity of P deficiencies. Most P fertility research in the region has concentrated on evaluating crop response to P application only during the first crop year after fertilizer P application. Multiple year observations of crop response to fertilizer P application are limited, especially for irrigated winter wheat. In this study, we evaluated the response of continuous winter wheat to P and N fertilization within reduced-till and no-till production systems under limited irrigation.

The plot area was located on a Weld silt loam soil near Akron, Colorado, with a pH of 7.1 and 1.4 percent soil organic matter. The plot area had been summer fallowed using conventional tillage the year prior to the first crop of winter wheat, then continuously cropped to winter wheat for two more years prior to establishing this P x N fertility study. Three winter wheat crops were produced following P application. Three rates of fertilizer P (0, 69, and 137 lb P_2O_5/A) were applied at planting time of the fourth winter wheat crop. The soil had an initial Olsen soil test P level of 5.7 parts per million (ppm), a low soil test rating in Colorado. Fertilizer N rates of 0, 50, 100, 200, and 300 lb N/A were also established with the fourth crop, anticipating a yield potential of more than 100 bu/A. Since this yield potential was not achieved with the fourth crop, fertilizer N rates were reduced for the fifth and sixth crops to 0, 30, 60, 120, and 240 lb N/A. Fertilizer P was applied only once in the study.

Fertilizer P (0-45-0) and fertilizer N (34-0-0) were broadcast applied and incorporated into the top 3 inches of soil with one pass with a tandem disk and one pass with a mulch treader just prior to planting the fourth wheat crop. No other tillage was performed following harvest of the third wheat crop. A no-till environment was used for the fifth and sixth crops. A randomized complete block split-plot design with three replications was used with P_2O_5 rates as main plots and N rates as subplots. High yielding winter wheat cultivars were grown during the study. A limited irrigation management program was used. Irrigation water was applied when more than 1.2 inches of soil water had been depleted from the soil profile. Irrigation was continued as needed until the soft dough kernel stage. **Table 1** summarizes the amount of growing season precipitation received, irrigation water applied, soil water use, and estimated crop water use.

Grain yields were increased each year by N and P fertilization (**Table 2**). The largest

TABLE 1. Estimated crop water use (evapotranspiration) each crop year (crops 4, 5, and 6) as a function of growing season precipitation, estimated soil water use, and irrigation water applied.

Wheat crop	Growing-season precipitation	Estimated soil water used	Growing-season irrigation water	Estimated crop water use
	....	.... inches	....	
Crop 4	6.85	7.76	1.50	16.10
Crop 5	7.01	0.04	5.91	12.96
Crop 6	8.35	2.76	1.38	12.49

increase came with the addition of the first increment of fertilizer N (either 30 or 50 lb N/A) with both P_2O_5 rates. Grain yields were near optimum with the application of 100 lb N/A the first crop after P fertilization and 60 lb N/A the second and third crop after P fertilization. Grain yields were greater with 69 lb P_2O_5/A than with 137 lb P_2O_5/A the first crop after P fertilization at all N rates. Analysis of the grain for zinc (Zn) concentration indicated that at the 137 lb/A P_2O_5 rate, Zn deficiency may have been a factor limiting yield with the first crop after P fertilization. With the second and third crops after P fertilization, grain yields were maximized with the 137 lb/A P_2O_5 rate.

The total three-year increase in grain yield above that of the check treatment (no P or N applied) for the N and P_2O_5 treatments is shown in **Figure 1** as a function of the total amount of N applied in three crop years (significant P x N interaction). Grain yields were increased a small amount by P application without N. Likewise, grain yield response to N application without P did not result in maximum grain yields. Both N and P fertilization were needed to optimize grain yield. **Figure 1** shows that for the three-year period, the 69 lb/A P_2O_5 rate resulted in a greater three-year yield increase than with the 137 lb/A P_2O_5 rate for the 110 lb/A total three-year N application. As the total N applied increased, the 137 lb/A P_2O_5 rate was needed to maximize yield potential. The three-year grain yields were near maximum with the total application of 220 lb N/A and 137 lb P_2O_5/A.

Crop water use (**Table 1**) was not influenced by the N or P treatments. Therefore, water use efficiency (bushels of grain produced per inch of water) was increased by the application of both N and P fertilizer since more grain was produced with the same amount of water.

The grain yield responses shown in **Table 2** and **Figure 1** indicate that response to fertilizer P application will occur more than one year. Phosphorus is relatively immobile in the soil and not subject to leaching like fertilizer N. The Olsen soil test P data in **Figure 2** show that the single applications of P increased soil test P levels throughout the duration of this study and probably for

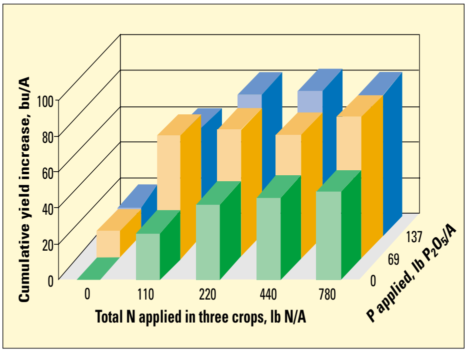

Figure 1. Cumulative yield above check treatment (no N or P added) of three irrigated winter wheat crops as a function of P and N fertilization.

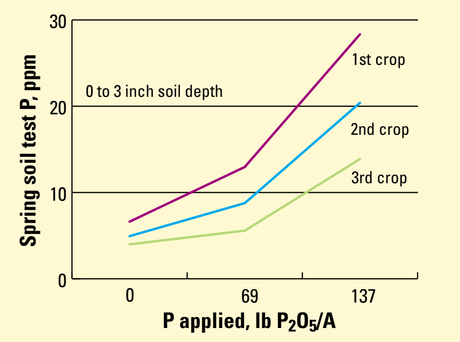

Figure 2. Spring soil test P (Olsen) levels each crop year following a single P fertilizer application.

TABLE 2. Winter wheat grain yields and net return to fertilizer application as a function of P_2O_5 and N fertilization treatments for three crop years (i.e., crops 4, 5, and 6).

Fertilizer treatment, lb/A		Grain yield, bu/A				Net return to fertilizer application, $/A			
P_2O_5	N rate[1]	Crop 4	Crop 5	Crop 6	Total	Crop 4	Crop 5	Crop 6	Total
0	1	25.4	35.6	23.6	84.6	0	0	0	0
0	2	40.4	39.8	31.0	111.2	28	5	13	45
0	3	49.2	43.6	34.7	127.5	40	8	16	63
0	4	55.5	42.8	32.7	131.0	35	-6	-1	28
0	5	55.6	46.1	32.6	134.3	15	-22	-26	-32
69	1	31.5	40.3	27.9	99.7	-2	12	11	21
69	2	56.8	56.8	39.1	152.7	51	47	33	131
69	3	62.5	53.2	40.3	156.0	56	32	30	117
69	4	65.2	49.4	38.8	153.4	42	11	14	67
69	5	70.1	53.1	39.8	163.0	35	-4	-8	23
137	1	30.6	42.2	28.4	101.2	-21	17	12	7
137	2	50.4	52.7	40.5	143.6	18	37	36	91
137	3	56.0	60.7	46.7	163.4	22	51	46	119
137	4	58.7	57.7	48.6	165.0	9	31	39	79
137	5	66.0	49.6	47.9	163.5	7	-13	13	7

[1] N rates for crop 4 were: 1 = 0; 2 = 50; 3 = 100; 4 = 200; 5 = 300 lb N/A; for crops 5 and 6: 1 = 0; 2 = 30; 3 = 60; 4 = 120; 5 = 240 lb N/A.

several more crop years.

The higher rate of P was needed to optimize wheat yields the second and third crops after application. Thus, application of P fertilizer to a P deficient soil can have long-term impacts on crop yields. In the northern Great Plains, Halvorson and Black (*Soil Science Soc. Am. J.*, 1985) reported responses to a single P fertilizer application for 17 years in a Montana, dryland cropping system. Economic returns to P application continued to increase with each additional year of cropping. Roberts and Stewart (*Better Crops*, 1988) reported similar results in Canada.

The economic returns to N and P fertilization were estimated for this study assuming that P_2O_5 was worth $.25/lb, N was $.20/lb, and winter wheat $2.50/bu. **Table 2** shows that P fertilization increased grain yields and net return to N fertilization. Although the P rates applied in this study were higher than those normally applied by Great Plains farmers, the economic data in **Table 2** show that the increased yields due to P fertilization were profitable the first crop year with N fertilization. Without N fertilization, the P applications were not profitable in the first crop year. With the first crop year after P fertilization, the highest profit potential was with the application of 69 lb P_2O_5/A and 100 lb N/A. With the second and third crops after P fertilization, the

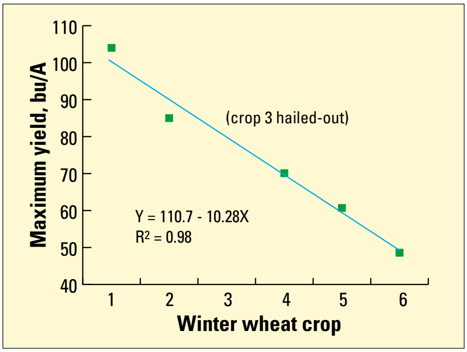

Figure 3. Change in maximum wheat yield with each additional crop of winter wheat.

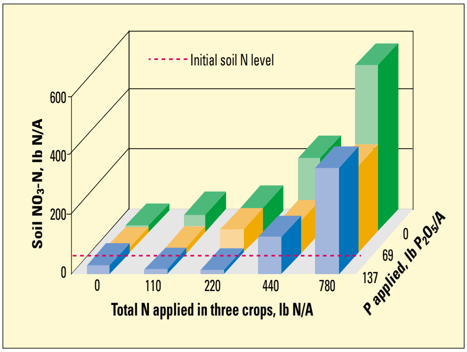

Figure 4. Residual soil NO_3-N level (0- to 4-ft. depth) after harvest of sixth wheat crop.

estimated net return to fertilization was greatest with the application of 60 lb N/A and the 137 lb/A P_2O_5 rate. Over the three-year period, cumulative net profits were greatest with the total application of 110 lb N/A and 69 lb P_2O_5/A. At the 137 lb/A P_2O_5 rate, the highest net return was with the total application of 220 lb N/A in three years. Continued cropping of the plots for several more years would more than likely have resulted in the greatest net return being with the 137 lb/A P_2O_5 rate. **Figure 2** shows that the one time application of P fertilizer improved soil test P levels for several years, with the 137 lb/A P_2O_5 rate still testing in the medium range the third crop year after P fertilization.

Maximum grain yields declined with each additional year of continuous winter wheat production on the plot area used in this study. **Figure 3** shows the decline in maximum grain yield attained each crop year. Downy brome grass competition increased with each additional year of winter wheat and with N and P fertilization. However, the downy brome was chemically controlled the last crop year, so competition with the wheat was minimized. In addition to the downy brome problem, other factors such as phytotoxic or allelopathic effects of the wheat residues on the next wheat crop may have contributed to the declining wheat yields. These observations show the importance of crop rotation as well as a good fertility program in maintaining optimum crop yields.

Application of P not only improved grain yields, but also improved N use efficiency. The residual soil NO_3-N levels in the 0- to 4-ft. profile after harvest of the last crop were lower with than without P fertilization (**Figure 4**). Note the large increase in residual soil NO_3-N when N application rates exceeded those needed for optimum grain yield (application of 440 and 780 lb N/A in three crops). Soil testing to determine N and P fertilization needs before nutrient application is important to optimizing yields and nutrient use efficiency and for protecting the environment from excess nutrient application.

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Site-Specific Nutrient Management...

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for no supplemental P or K. However, with more intensive sampling and yield goal assessment, approximately 73 acres (46 percent) were identified as needing additional P, and 76 acres (48 percent) required additional K. The recommended rates per acre for each management zone are shown in **Figure 4**.

Total field requirements of 4,740 lb of P_2O_5 and 4,895 lb of K_2O were identified by the zone management plan, but were missed by whole field sampling and yield goal determination.

These two examples demonstrate the possibilities of precision agriculture in refining nutrient management. How often such disparities exist between whole-field and site-specific nutrient management has not been well assessed in many regions. Fields with known "hotspots" or areas with very high soil test levels are currently considered good candidates. The range in soil test levels is also important. Variability occurring at levels higher than those requiring additional nutrients is not cost-effective for site-specific nutrient management. However, wide ranges that include soil test levels requiring additional nutrients are thought to benefit from more refined approaches.

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KENTUCKY

New Technologies and Analytical Tools for Fertilizer Recommendations?

By E.M. Pena-Yewtukhiw, J.H. Grove, J.A. Thompson, and C.E. Kiger

Gathering information about soil fertility status and the purchase and application of fertilizers and soil amendments can result in considerable nutrient management costs. Information gathering usually consists of plant and/or soil sampling, analysis, and interpretation. Soil sample analysis is particularly important to traditional phosphorus (P), potassium (K) and pH management. Soil sampling, testing, interpretation, and recommendation development require skill and time, time that may be in short supply when crop harvest is soon to be followed by establishment of a succeeding crop. Is there a better way?

Spatially referenced yield monitoring, coupled with a measure of grain composition, can give a "nutrient removal map" that can be the basis of the next fertilizer prescription. Using tabular estimates for grain P and K composition, nutrient removal/fertilizer prescription maps could be developed directly from a field's yield map. Intuitively, nutrients would be applied where needed, as needed. If tabular estimates were thought inappropriate, one could sample the grain, either spatially or to create a random composite. Spatially referenced grain sampling requires time and skill comparable to that for grid soil sampling. However, there is no reason to believe that grain composition is constant across the field or that it will exhibit a spatial pattern similar to that for grain yield or the soil test nutrients.

> Developing fertilizer recommendations can be one of the more important and costly tasks undertaken as part of a site-specific management plan. New technologies can help, but also complicate, fertilizer recommendation development. The traditional soil test approach can be intensified with site-specific analysis. A crop nutrient removal approach might be based on spatially referenced yield monitoring, but requires some information on grain composition. Among the spectrum of alternatives, which is the "best"?

Limiting factors other than nutrient stress often drive yield differences within the field. For example, should this year's weed competition pattern, which has a negative effect on yield, drive fertilizer application for the next crop? If yield was low in part of the field because of low soil test P, should the fertilizer P rate for that area be based on the yield and P removal? New technologies such as the yield monitor and spatial analysis may help to improve fertilizer recommendations, but how do they compare with the existing options?

The objective of our study was to compare five alternative approaches for generating fertilizer rate prescriptions for P and K. These approaches were: a) our "expensive standard", based on grid soil sampling and spatial soil analysis; b) based on a single composite soil sample, created from the average of the grid soil samples in a field; c) based on a yield map, single values for grain P and K taken from a published table, and spatial analysis of nutrient removal; d) based on a yield map, single values for grain P and K from a single composite sample created from the average of the grid grain samples taken in a field, and spatial analysis of nutrient removal; and e) based on a yield map, grid grain samples taken in the field, and spatial analysis of both grain composition and nutrient removal.

TABLE 1. Fertilizer recommendations as related to removal

Fertilizer recommendation, lb/A	Removal, lb/A		Soil test, lb/A	
P_2O_5 or K_2O	P_2O_5	K_2O	P	K
0	0-15	0-15	> 56	> 300
30	15-45	15-45	42-56	225-300
60	45-75	45-75	28-42	175-225
90	75-105	75-105	14-28	100-175
120	105-135	105-135	0-14	< 100

TABLE 2. Soil test, yield, and grain composition information.

Property	Field 112	Field 950
P (M3)	53.9 ± 30.9	147 ± 64
K (M3)	429 ± 158	392 ± 121
OM	2.57 ± 0.44	3.26 ± 0.56
pH	6.32 ± 0.60	6.41 ± 0.27
Clay	19.5 ± 3.9	17.7 ± 2.8
Silt	71.2 ± 4.3	72.8 ± 3.3
Sand	9.2 ± 9.1	9.5 ± 1.8
Yield, bu/A	130.4 ± 46.9	137.6 ± 22.4
Grain P, %	0.29 ± 0.04	0.35 ± 0.03
Grain K, %	0.33 ± 0.03	0.41 ± 0.03

Methodology

Two fields, designated 112 (51.4 acres) and 950 (43.4 acres), were chosen. Both fields were planted to corn, without prior tillage, in April 1999. In both fields the dominant soil is well drained, but both also contain significant areas of only moderately well drained soil. Field 112 had a history of mineral fertilizer applications and 950 had a history of swine manure and fertilizer nitrogen (N) applications. Corn yield was determined with a calibrated yield monitor on a combine equipped with Global Positioning System (GPS) technology. Grain and soil samples were taken at the same point, on a 180 x 200 ft. grid, prior to and after harvest, respectively. A digital elevation map was generated for each field. Soil samples were analyzed for extractable P and K (Mehlich 3), water pH, soil organic matter, and texture. Grain tissue was analyzed for total P and K.

Geostatistics were used to characterize the spatial variation in crop yield, nutrient composition, and soil properties within a field. The grain yield at the soil/grain sampling points was determined by averaging the yields at the four points nearest each grid sampling point. The tabular values used to calculate nutrient removal and fertilizer prescription maps were 0.326 percent P = 0.353 lb P_2O_5/bu and 0.221 percent K = 0.267 lb K_2O/bu (assuming 15.5 percent field moisture corn). **Table 1** shows the fertilizer rate recommendation as related to nutrient removal or soil test nutrient values.

Maps for each fertilizer rate prescription alternative were constructed. The nutrient removal/prescription maps were developed by: a) multiplying the yield by grain P and K at each grid sampling point and using an interpolation method (kriging) to predict values at all unsampled points in the field; b) same as a), above, but using the tabular grain P and K concentration information; and c)

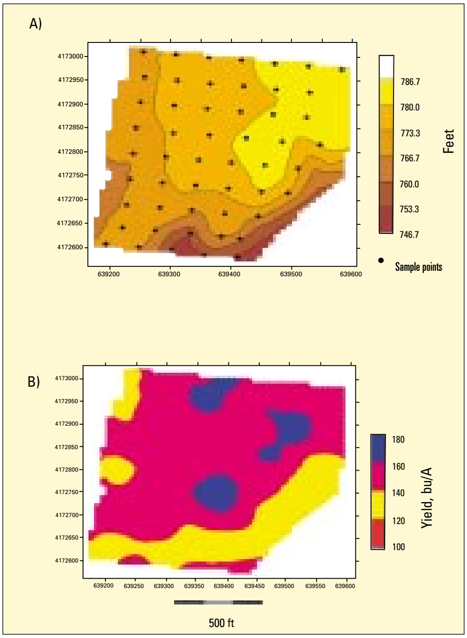

Figure 1. Field 950 A) elevation and sampling points; B) map of yield (interpolated).

same as a), above, but using the average grain P and K concentration found for the grid grain samples. The same interpolation method was used on the grid soil test P and K data in order to develop soil test based fertilizer prescription maps. Average P and K soil tests, using all the grid soil samples, were considered in arriving at a single prescription rate for the field.

TABLE 3A. Portion of field 950 (%) receiving each fertilizer P rate,

Fertilizer recom-mendation, P_2O_5	Grid soil test P	Composite soil test P	Removal tabular grain P	Removal grid grain P	Removal composite grain P
lb/A	%				
0	100	100	0	0	0
30	0	0	38.4	30.5	23.3
60	0	0	61.7	69.5	76.7
90	0	0	0	0	0
120	0	0	0	0	0

TABLE 3B. Portion of field 950 (%) receiving each fertilizer K rate,

Fertilizer recom-mendation, K_2O	Grid soil test K	Composite soil test K	Removal tabular grain K	Removal grid grain K	Removal composite grain K
lb/A	%				
0	78.6	100	0	0	0
30	21.2	0	99.0	100	0
60	0.2	0	1.0	0	67.0
90	0	0	0	0	33.0
120	0	0	0	0	0

Observation

"Composite" soil test, grain yield, and grain tissue P and K information for the two fields are given in **Table 2**. On average, Field 112 is lower than 950 in soil test P and organic matter, but higher in soil test K. Texture and pH were more similar. Grain yield was lower and more variable in 112 than 950. For both fields, grain P was close to the tabular value; however, grain K was well above the tabular value.

Topography, soil properties, and yield were variable, but were spatially related, in each field. In general, lower elevation and decreased drainage capacity were related to lower corn yields. **Figure 1 (A** and **B)** shows sampling point locations, elevations, and yield (interpolated) in field 950. Grain P and K were spatially autocorrelated, but were not well related to yield or other soil properties (data not shown). Considerable variation in soil test P in field 950 is shown in **Figure 2A**, but no fertilizer P would be recommended because there were no areas with a soil test P value below 56 lb P/A. The removal fertilizer prescription map, using the yield map and the tabular grain P concentration (**Figure 2B**), delimits two areas with rate prescription differences due to large yield differences. The removal fertilizer prescription maps obtained using the grid or the "composite" of grain P

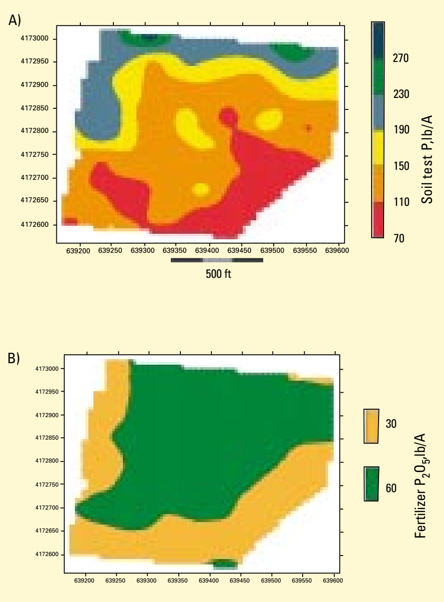

Figure 2. Field 950 A) map of soil test P; B) fertilizer P prescription from P removal using tabulated grain P concentration.

and K values actually measured in field 950 were similar to prescription maps based on the tabular grain P value. Comparing the five methods of arriving at a P recommendation for field 950, removal fertilizer prescriptions always called for more fertilizer than the soil test prescriptions on this manured field (**Table 3A**). Areas in the removal maps calling for the greatest fertilizer P recommendation were often those areas with higher soil test P (**Figure 2 A** and **B**). “Composite” soil analysis called for no fertilizer P or K for 950.

TABLE 4A. Portion of field 112 (%) receiving each fertilizer P rate,

Fertilizer recommendation, P_2O_5	Grid soil test P	Composite soil test P	Removal tabular grain P	Removal grid grain P	Removal composite grain P
lb/A	%				
0	30.5	0	0	0	0
30	36.0	100	43.1	94.5	74.1
60	31.7	0	56.5	5.5	25.9
90	1.7	0	0.5	0	0
120	0	0	0	0	0

TABLE 4B. Portion of field 112 (%) receiving each fertilizer K rate,

Fertilizer recommendation, K_2O	Grid soil test K	Composite soil test K	Removal tabular grain K	Removal grid grain K	Removal composite grain K
lb/A	%				
0	79.2	100	0	25.2	0
30	15.9	0	92.4	68.8	22.4
60	4.3	0	7.6	5.9	74.9
90	0.6	0	0	0	2.7
120	0	0	0	0	0

Using the same five methods to arrive at a K recommendation for field 950 (**Table 3B**), a similar pattern of bias error, resulting in greater fertilizer recommendations with removal prescriptions, was observed. However, there were some differences between soil test and removal approaches. Grid soil sampling identified some areas needing K, relative to the composite soil sample. The composite grain sample resulted in a greater K prescription relative to the other two removal approaches (**Table 3B**).

The soil test K map for field 112 (**Figure 3A**) also showed considerable variation. Lower soil test K was associated with the moderately well drained soil and resulted in a fertilizer K prescription that was not called for on the rest of the field (**Figure 3B**). Comparing recommendation approaches for this field, more fertilizer P and K were prescribed, relative to that recommended by grid soil sampling, by the three removal approaches (**Tables 4A** and **4B**). The “composite” soil analysis recommended no K fertilizer and a uniform rate of 30 lb P_2O_5/A for this field. Relative to grid soil sampling, this P

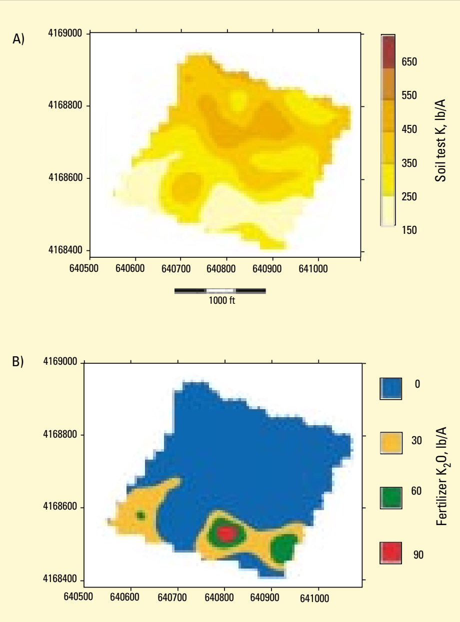

Figure 3. Field 112 A) map of soil test K; B) fertilizer K prescription from soil test K.

recommendation appears appropriate for a third of the field, over-fertilizes a third of the field, and...most seriously...under-fertilizes a third of the field. However, these seemingly equal divisions among the recommended P fertilizer rates were not so uniformly distributed across field 112 (map not shown).

Conclusion

In this study, it appeared that composite soil sampling was not necessarily inferior to grid soil sampling in terms of the resulting fertilizer P or K recommendations. In general, the nutrient removal-based prescription maps resulted in greater recommendations than either soil test approach. We also observed that our chosen tabular grain P and K concentrations resulted in prescription maps that were sometimes very different from those developed using P and/or K concentrations taken from a field's grain samples. Our results suggest that using spatially referenced yield information and tabular grain concentration information to develop fertilizer P and K rate prescription maps rests on possibly invalid assumptions. Problematic assumptions include: a) that the field's grain composition is generally uniform and close to that given in the chosen table, and b) that the demand of the past crop, rather than the current supplying power of the soil, is well related to the need for fertilizer for the next crop. We speculate that the yield map might be used to stratify a field into more uniform "management zones", which would then be randomly soil sampled for optimal nutrient management information. We are evaluating this option at present. BC

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Donald L. Armstrong, Editor

Harold F. Reetz, Jr. Honored with ASA Agronomic Industry Award

Harold F. Reetz, Jr.

Dr. Harold F. Reetz, Jr., Midwest Director of PPI, received the Agronomic Industry Award at the recent annual meeting of the American Society of Agronomy (ASA) in Minneapolis. The award recognizes outstanding performance by a private sector agronomist in the development, acceptance, and implementation of advanced agronomic programs, practices, and/or products.

Dr. Reetz is widely recognized for leadership in promoting the use of site-specific systems and information technology in support of high-yield crop and soil management.

Before joining the staff of PPI in 1982, he was Extension/Research Corn Production Specialist in the Purdue University Agronomy Department for eight years and coordinated Extension and research in computer applications in agronomy.

A native of Milford, Illinois, Dr. Reetz earned his B.S. degree from the University of Illinois and M.S. and Ph.D. degrees from Purdue University in crop physiology and ecology. He has been active in ASA, with leadership roles in ARCPACS and in development of the Certified Crop Adviser (CCA) program. He served as editor for *Agronomy Journal* and *Journal of Production Agriculture*, and has served on a variety of committees. He is Fellow in both ASA and the Crop Science Society of America.

As Midwest Director of PPI, Dr. Reetz has responsibility for agronomic research and education programs in the states of Illinois, Indiana, Ohio, and Michigan. BC

B.C. Darst Receives ASA Agronomic Service Award

B.C. Darst

Dr. B.C. Darst, Executive Vice President of PPI, received the Agronomic Service Award at the recent annual meeting of the American Society of Agronomy (ASA) in Minneapolis. The award recognizes development of agronomic service programs, practices, and products and acceptance thereof by the public.

Dr. Darst joined the staff of PPI in 1973 as Southwest Director. Previously, he was Supervisor of Soil and Plant Testing, Chief Agronomist, and Regional Sales Manager with Custom Farm Services in Atlanta and Albany, Georgia. He helped design and managed the world's first high volume, automated, and computerized soil testing laboratory. Many of its technological advancements have served as models for laboratories being operated today.

In 1978, Dr. Darst wrote PPI's well known *Soil Fertility Manual*. Since that time, it has been revised and reprinted several times. It has been translated to Spanish, French, Portuguese, Chinese, and Hindi, and a new adaptation was recently completed in Australia. The manual has been widely used in teaching and is now a popular study resource for the Certified Crop Adviser program.

Dr. Darst was appointed Vice President of Communications for PPI and elected Vice President and Executive Director of the Foundation for Agronomic Research (FAR) in 1986. He served as President of FAR from 1988 to 1999. Dr. Darst was elected Executive Vice President of PPI in 1992.

He is Fellow in both ASA and the Soil Science Society of America. BC

The New Millennium… and remembering the good old days

Last year about this time, I made reference to the fact that three or four colleagues and I believed there had been a 365-day rush on the beginning of the Third Millennium. Well, we've been joined by a few others who think that, effective January 1 of 2001, we are actually there. In fact, there have been references to the *scientific* new millennium now upon us. You could say I've made this too much of an issue, but a new 1,000 year-period doesn't come along that often…and that puts the issue of remembering the good old days in a whole new light.

Recent winter ice and snow storms across much of the U.S. were devastating. People went without power and heat for as long as two weeks. For many, drinking water supplies were also disrupted. Storms caused several deaths, states of emergency were declared, and hundreds of thousands were forced to survive without modern conveniences.

The storms and reports I watched on TV and read in the news took me back to the middle of the last century and southeastern Oklahoma. We had severe ice a couple of winters in a row. I can remember how serious it was because KSEO 750 in Durant was off the air for a while. The storm didn't affect our battery operated radio, but it put the station, dependent on electricity, out of commission. Schools were also closed…good news!

Things didn't change much at our house though, except that it was tough beating the ice off the woodpile to get fuel for our cook stove and 'heater.' There was always a good supply of kerosene ('coal oil' as we called it) to light the lamps and start the fires, and our water came from a well.

There is no way I want to go back to 'the good old days.' I like running water, electricity, air conditioning, and cable TV, even if they are occasionally disrupted. While progress has brought some problems, it has changed all our lives in ways much more positive than negative. That includes modern production agriculture. When one looks at food production today and compares it to that of a half century ago, he or she could hardly be objective in suggesting that we aren't much better off now. Yet, there are those detractors who continue to criticize and encourage a throwback to an agriculture of 50 or more years ago. They don't have scientific evidence to support their rhetoric, but that hasn't stopped them yet.

Now that the new millennium is undeniably here, perhaps the detractors of modern agriculture can find a new agenda. I wouldn't bet on it, because there are still folks who refuse to give up on the good old days.

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