BETTER CROPS WITH PLANT FOOD

1995 Number 2

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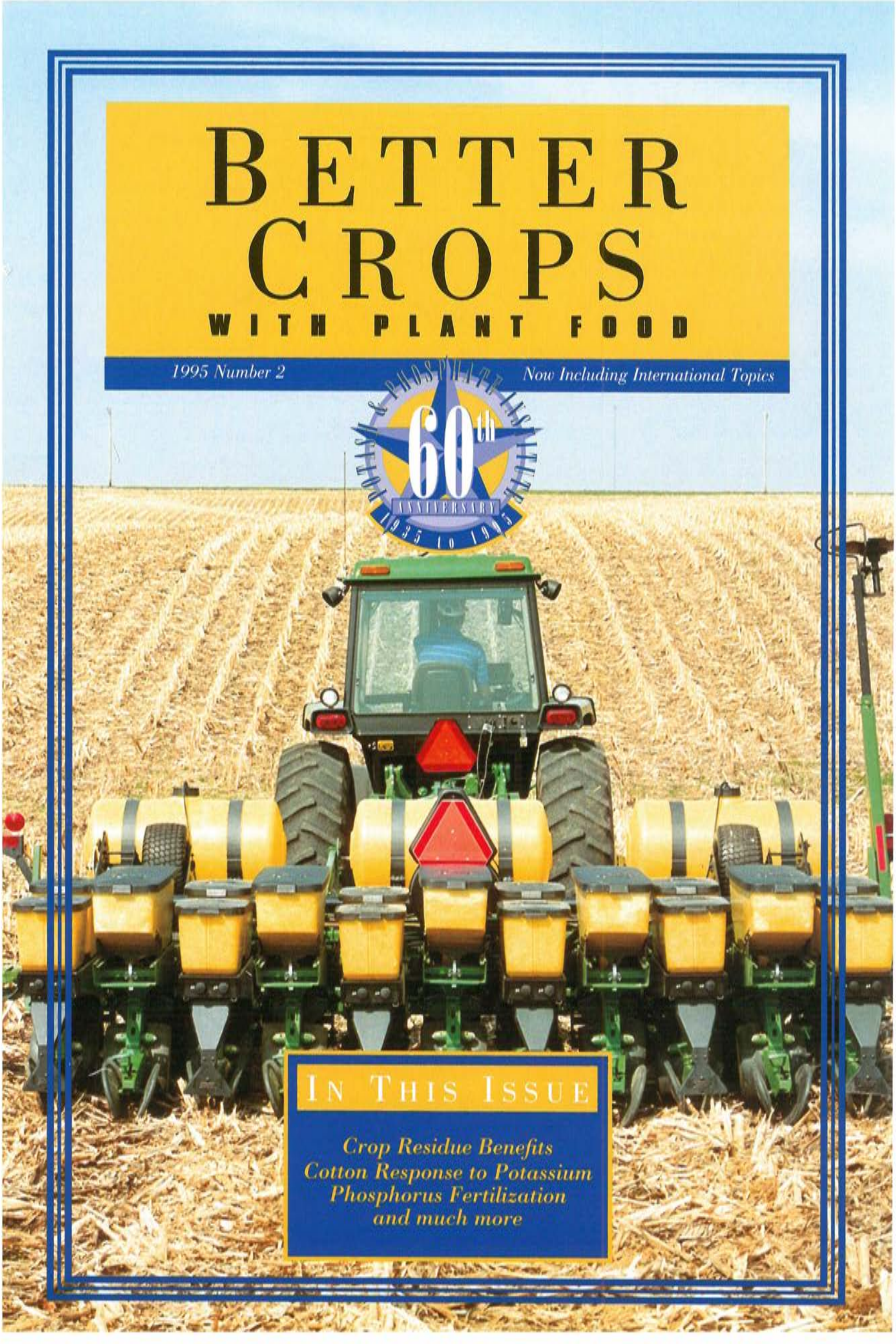

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Crop Residue Benefits
Cotton Response to Potassium
Phosphorus Fertilization
and much more

BETTER CROPS
WITH PLANT FOOD

Vol. LXXIX (79) 1995, No. 2

Our Cover: Each year, more acres of crops are planted in reduced tillage systems. Conditions involving more crop residue on the surface help reduce erosion, but require careful management for good yield results.
Photo: Courtesy of Deere & Company
Design: Rick Robbins Design

BETTER CROPS WITH PLANT FOOD
(ISSN:0006-0089) is published quarterly by the Potash & Phosphate Institute (PPI). Application to mail at Second Class postage rates is pending at Norcross, GA, and at additional mailing offices. Subscription free on request to qualified individuals; others $8.00 per year or $2.00 per issue. POSTMASTER: Send address changes to **Better Crops**, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2834. Phone (404) 447-0335; fax (404) 448-0439.

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Information Agriculture Conference on Site-Specific Integrated Crop Management Systems Set for June 27–30

THE POTASH & PHOSPHATE INSTITUTE (PPI) is coordinating plans for a program June 27 through 30, 1995, spotlighting several new technology tools for modern crop production. It is called **"Information Agriculture: A Conference on Site-Specific Integrated Crop Management Systems and Electronic Communications for Agriculture."** The event will be held at the Chancellor Hotel & Convention Center, Champaign, IL.

Field and laboratory demonstrations of equipment and services available from agribusinesses, universities and government agencies will also be featured, along with discussion sessions and visits to farmers who are using site-specific and electronic communication technologies.

The last three days (June 28, 1:00 pm through June 30, 12:00 noon) will be devoted to a conference of invited speakers and volunteer poster sessions. One display will show progression through the growing season of an integrated system of technology applied to site-specific crop management. It will be presented by leaders in the development of the different components. Alternatives, missing links, and potential pitfalls will also be noted.

Some of the topics, tours and exhibits include:

- Illini FS VRT Center: Site-Specific Nutrient and Pest Management Systems; Yield Mapping, Grid Sampling, Variable Rate Application
- CYBERFARM: A demonstration of a rural community information network
- National Center for Supercomputer Applications GIS Laboratory
- Natural Resources Conservation Service mapping and GIS activities and services
- Maintaining integrity of data; ownership, access; pedigree; anonymity of source
- Expert Systems as a management tool. Examples of real-world applications
- Record systems; Infielder, AGRIS
- Internet access
- Mapping systems; GIS, GPS, remote sensing; What they do and don't do
- Legal issues of site-specific management and data handling
- Integrating all of the pieces into a management and information system

The conference will include opportunities to earn continuing education credits for the Certified Crop Adviser (CCA) program.

The program is co-sponsored by the University of Illinois College of Agriculture, National Center for Supercomputer Applications, Illinois Fertilizer & Chemical Association, CCNet Agriculture Committee, The Fertilizer Institute, Agricultural Retailers Association, Foundation for Agronomic Research, Agricultural Education & Consulting, American Society of Agronomy, *Successful Farming*, *ag/INNOVATOR*, John Deere Precision Farming Group, Pioneer Hi-Bred International, Inc., AGRIS Corporation, TopSoil Testing Service, RDI Technologies, Inc., Rockwell International, Illini FS, Conservation Technology Information Center, *Farm Chemicals*, PACE, *Application Technology, Dealer Progress*, Ag Electronics Association, INFIELDER Crop Record System, USDA–Natural Resources Conservation Service, and Center for Complex Systems Research of the Beckman Institute.

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Crop Residue Removal and Fertilizer Effects on Crop Yield and Soil Sustainability

By Keith A. Janssen and David A. Whitney

Kansas studies emphasize the importance of crop residues and adequate soil fertility in maintaining yields and soil organic matter levels.

CROP RESIDUES are being considered as a source of raw materials for various non-agricultural uses. But crop residues also are needed for surface soil cover and to replenish soil organic matter.

Many grain producers currently harvest crop residues for livestock feed or other farm uses with little noticeable negative effects. Generally, this is not done on an every year basis from the same field. Also, some of these plant materials may be returned to the field as animal wastes. The potential for influencing crop and soil sustainability could be much greater with non-agricultural crop residue uses.

The first concern when crop residues are removed is with soil erosion protection and whether conservation compliance will be jeopardized. Residue removal can also affect soil water conservation and storage. Residue removal can deplete plant nutrients, deplete soil organic matter, and change soil physical properties. The effects of fertilizer management in offsetting plant nutrient losses when crop residues are removed is not well understood.

Kansas Study

This study was established to determine the effects of returning varying levels of crop residue on crop yields and soil properties in a soybean-wheat-grain sorghum rotation, fertilized with variable rates of nitrogen (N), phosphorus (P) and potassium (K).

The study at the East Central Kansas Experiment Field on a nearly level (0 to 1 percent slope) Woodson silt loam soil included residue treatments begun in the fall of 1980 and continued for 12 consecutive years using a soybean–wheat–grain sorghum cropping sequence. Only one crop was grown each year. Residue treatments were: 1) residue removed each year after grain harvest; 2) normal crop residue incorporated; and 3) twice normal residue incorporated. Fertilizer treatments listed in **Table 1** . . . zero, low, normal and high levels of N-P-K for the three crops . . . were superimposed on residue treatments.

Table 1. N-P-K fertilizer treatments for crops in rotation.

Fertilizer treatments	Soybean	Wheat	Grain sorghum
	----------	$N\text{-}P_2O_5\text{-}K_2O$, lb/A	----------
Zero	0-0-0	0-0-0	0-0-0
Low	0-0-0	25-15-25	50-15-25
Normal	0-0-0	50-30-50	100-30-50
High	0-0-0	75-45-75	150-45-75

Grain yields and residue yields were measured each year. Soil samples (0 to 6-inch depth) were collected after the 11th year for chemical analysis. Soil bulk density measurements were also performed on the 0 to 4-inch depth. A disk-field cultivate tillage system was used for seedbed preparation and residue incorporation all years.

The Results

Grain yields and residue yields varied with crop and year. Soybean yields ranged from 14 to 53 bu/A, residue yields ranged from 0.34 to 0.81 tons/A; wheat

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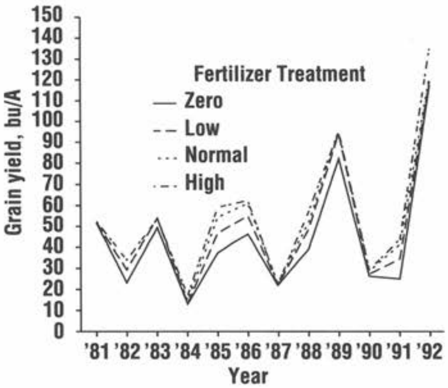

Figure 1. Effects of fertilizer applications on grain yield.

yields ranged from 29 to 50 bu/A, residue yields from 0.99 to 1.47 tons/A; and grain sorghum yields ranged from 54 to 129 bu/A, residue yields from 1.11 to 2.66 tons/A. Crop residue yields, like those of grain, vary substantially with growing season. Although direct residue production comparisons are not valid because all crops were not grown in the same year, grain sorghum produced the highest overall average amount of residue, 1.69 tons/A, wheat 1.20 tons/A, and soybean 0.57 tons/A.

The residue treatments caused no statistically significant differences in grain yield for any crop in any year. Neither the removal of crop residue nor the adding

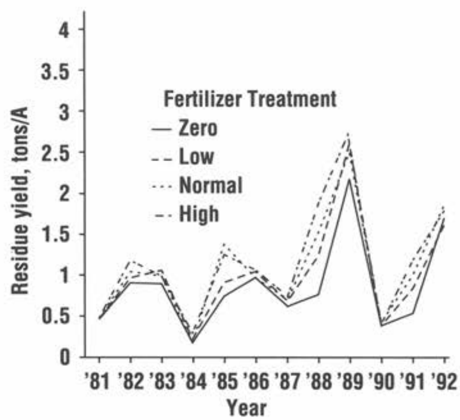

Figure 2. Effects of fertilizer applications on residue yield.

INCREASED crop residues result from better fertilization practices and higher yields. The benefits are better erosion control, increased soil organic matter and improved moisture infiltration.

of twice normal crop residue influenced crop yield.

Fertilizer increased both grain and residue yields, shown in **Figures 1 and 2**.

Generally, highest grain and residue yields were produced with the normal and high fertilizer treatments.

Soil analyses after 11 years of residue-fertilizer treatments indicated significant differences in exchangeable K, bulk

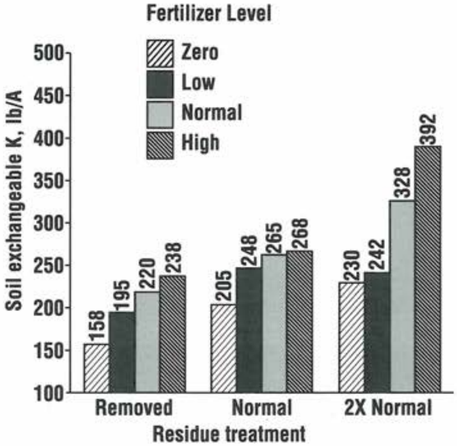

Figure 3. Soil exchangeable K after 11 years of residue and fertilizer treatments.

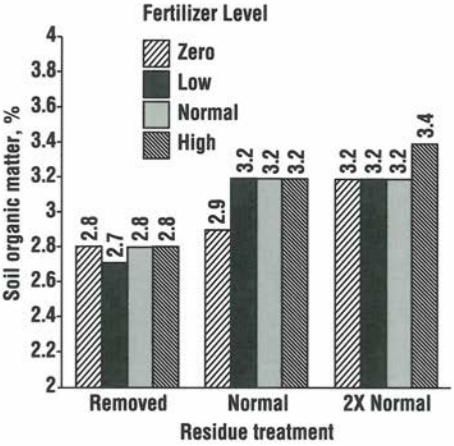

Figure 4. Soil organic matter after 11 years of residue and fertilizer treatments.

density (data not shown), and organic matter due to residue treatments. There was a statistically significant interaction between the residue and fertilizer treatments for exchangeable K, **Figure 3**.

Exchangeable K was affected most by the residue treatments. Exchangeable K decreased when crop residue was removed. Doubling crop residue increased exchangeable K, especially when higher levels of K fertilizer were applied. This was because the high K content of the residue plus the fertilizer K exceeded crop K removals.

Soil organic matter decreased with crop residue removal and with normal residue incorporated when no fertilizer was applied, **Figure 4**. Doubling crop residue increased soil organic matter. Doubling crop residue in combination with high fertility produced the most residue and the highest soil organic matter levels. Organic matter in the soil is a result of the balance between loss from decomposition and gain from crop residues and roots returned to the soil. Soil bulk density increased slightly with removal of crop residue and decreased slightly with doubling of crop residue. This is likely a reflection of the differences in soil organic matter levels.

Summary

The results of this study suggest that in situations where soil erosion and soil water relations are of little concern, removal of crop residues should not affect crop yield over the short term. Removal of crop residue will, however, slightly lower soil organic matter and will increase soil bulk density compared to normal residue incorporation. These slowly occurring effects are potentially long-term serious factors. Removal of crop residue will require application of extra K in the relatively short term because of the high K content of residues.

Long-term, continuous residue removal remains questionable. That's because long-term removal could cause further decline in soil organic matter, increased soil physical problems and eventually affect crop yield.

In different environments with different soils, the effects of removing crop residue could be much different. This soil was initially high in soil organic matter for the area and had medium to high levels of soil fertility. Soils with lower organic matter and lower fertility would likely be affected more quickly by crop residue removal. ■

New Jersey

Chloride Suppresses Corn Stalk Rot

By Jospeh R. Heckman

Research in New Jersey continues to indicate that chloride (Cl) may have a significant role in suppression of stalk rot in corn.

STALK ROTS are widespread diseases that reduce corn yield and quality. Lodging caused by stalk rot increases harvest losses and makes harvesting more difficult.

Evidence that stalk rot may be reduced by Cl fertilizers was first obtained from field experiments in New York during the 1950s. Field experiments were recently conducted in New Jersey to evaluate the economic importance of Cl to corn grown under high yield conditions. Chloride fertilization was found to significantly decrease stalk rot in one of two years while producing significant yield increases. In 1992, 11 percent of the control plants were affected by stalk rot versus only 4 percent of the plants receiving Cl.

To further evaluate Cl effects on the incidence of stalk rot, another study was conducted in 1994 at the Rutgers Plant Science Research Station in Adelphia, NJ. The experiment attempted to provide a maximum yield environment by use of irrigation, narrow rows (12 in.) and high plant population (43,560 plants per acre; Pioneer Hybrid 3245). Applications of nitrogen (N), phosphate (P_2O_5) and potash (K_2O) totaled 500, 268 and 405 lb/A for the season, applied at planting and during the growing season. Boron (B), copper (Cu), manganese (Mn) and zinc (Zn) were also supplied at planting. Adequate sulfur (S) was assured by supplying N as ammonium sulfate.

The control used potassium sulfate (K_2SO_4) to supply a constant amount of K (405 lb K_2O/A). Chloride at a rate of 360 lb Cl/A was provided by potassium chloride (KCl). Equal amounts of potassium (K) were supplied to each treatment. Stalk rot was evaluated at harvest by examining the first fully elongated internode above the brace roots.

Results

Less than half as many plants had stalk rot where Cl was applied, as shown in **Table 1**. The difference was highly significant statistically ($p<0.001$). The moisture content of the stover was greater in plants fertilized with Cl. Chloride helps plants retain water and slightly delays plant maturity. Chloride may reduce stalk rot by preventing premature death of corn plants.

Table 1. Effect of Cl fertilization on corn grain yield and stalk rot, 1994.

Treatment, lb Cl/A	Stalk rot, %	Grain yield, bu/A	Ear moisture, %	Stover moisture, %
0	20	244	28.2	69
360	9	253	28.7	73

Although previous experiments at Adelphia in 1990 to 1992 showed significant yield increases from Cl fertilization, the 1994 yield increase of 9 bu/A was not statistically significant. These yields were determined by hand harvest. If they had been determined by machine, the harvest losses from the zero Cl treatment would have been larger because of lodging.

Potassium chloride (KCl, 0-0-60) contains 45 to 47 percent Cl. Corn also needs adequate K to produce strong stalks. Corn growers experiencing problems with stalk rot and lodging may want to evaluate their fertilizer program for both K and Cl. Soil tests and plant analysis should be used to determine the amount of K to apply. Soil tests for Cl are not commonly available but can be obtained by special request. Because Cl is easily lost from coarse textured soils by leaching, spring applications of KCl are advised where leaching is a problem. ■

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Soil Test Nitrogen and Phosphorus Variability in the Texas Southern High Plains

By M. G. Hickey and A. B. Onken

Texas data demonstrate variability in phosphorus (P) distribution in apparently uniform fields. Application according to grid sampling provides opportunity for increased input efficiencies and higher yields.

THE Texas Southern High Plains represents about 25 percent of the planted cotton in the U.S. About 50 percent of the production area is farmed dryland, and the remaining cropland receives varying amounts of irrigation. Most of the farms are large, with individual fields generally 120 acres or more in size.

Many producers consider their fields to be quite uniform, but most generally recognize that yields vary across the field. From a soil series standpoint, many fields across the area are quite uniform. Soil fertility levels, however, can be quite variable on the small scale, a fact which can only be revealed through intensive soil sampling and geostatistical modeling.

Ag-CARES Study

In this study, the Agricultural Complex for Advanced Research and Extension Systems (AG-CARES) in Dawson county, TX, was selected. The 160-acre AG-CARES facility has 120 acres irrigated (center-pivot system) and 40 acres devoted to dryland systems. The entire site is mapped as Amarillo fine sandy loam, with a 0 to 3 percent slope.

The AG-CARES site shown in **Figure 1** was subdivided into a 9x9 grid, with each block representing 2 acres. Three one-inch diameter cores were collected from near the middle of each block, and composited (only the 0 to 6 inch depth samples will be discussed). Composite samples were analyzed for soil test nitrogen (N) and P at the Texas Agricultural Extension Service Soil Testing Laboratory at Lubbock. The data were then subjected to an appropriate geostatistical model, and maps were developed.

Most Texas Southern High Plains fields are sampled in order to make a single fertilizer rate application. **Table 1** shows calculated field mean soil test N and P levels as a function of sample number. All concentrations were comparable across sampling number, and all had the same nutrient rating. These results would indicate that the 160 acre field was quite uniform.

Table 1. Comparison of soil test N and P as a function of sample number and means of selecting samples.

	Soil test N, ppm	N Rating	Soil test P, ppm	P Rating
5 Taken at Random	2.2	Very Low	20	Low
10 Taken at Random	2.3	Very Low	17	Low
25 Taken at Random	2.6	Very Low	16	Low
All 81	2.5	Very Low	6	Low

The soil test N distribution across AG-CARES was quite uniform, with only 10 acres rated higher than very low (**Table 2**). This result was expected, because of N uptake from the previous crop and downward movement of nitrate-N (NO_3-N) from the surface 6 inches in sandy soils. Adequate N fertilizer recommendations

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Figure 1. Aerial photograph of the AG-CARES facility, in Dawson county, TX.

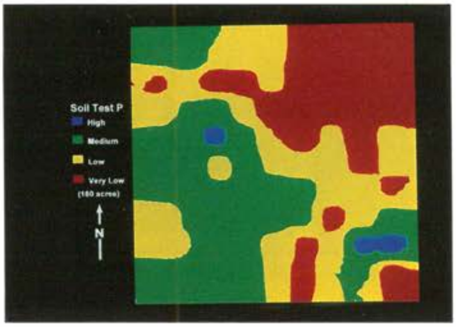

Figure 2. Map of soil test P distribution at AG-CARES, Dawson county, TX.

could be made with a relatively few soil samples. For 2 bale/A cotton, 95 lb N/A across the entire field would be recommended.

Unlike N, the soil test P distribution across AG-CARES was much more variable, as shown in **Figure 2**. The variation in soil test P was divided nearly evenly between very low, low, and medium (**Table 2**). The majority of acres testing very low in P were identified with the Northeast quadrant, that is characterized by a 3 percent slope. The areas testing low and medium had no visible characteristics. Two P "hot spots" were observed, but there is no readily apparent reason for their occurrence.

With the amount of spatial variability in soil test P across AG-CARES, a single rate fertilizer application could lead to loss of potential revenue. Based on the 25 random samples shown in **Table 1**, 25 lb P_2O_5/A would be recommended for 2 bale/A cotton. This would amount to about 4,000 lb P_2O_5 applied to the 160 acre field as a single application. If spatial variability is accounted for, the 45 acres testing very low would receive 65 lb P_2O_5/A, and the 53 acres testing low would have 25 lb P_2O_5/A applied.

Table 2. Soil test N and P distribution based on 2 acre grid sampling and geostatistical mapping.

Soil test rating	Nitrogen, acres	Phosphorus, acres
Very Low	150	45
Low	6	53
Medium	4	61
High	<1	1

When the distribution of soil test P at AG-CARES is accounted for, no P fertilizer would be applied to the 62 acres testing medium and high, where no response is anticipated. If the single field rate were used, then about 1,550 lb P_2O_5 would be applied with no anticipated response. Use of the single field rate would have shorted the 45 acres testing very low by about 40 lb P_2O_5/A, which would have effected a reduction in the potential yield. When spatial variability is taken into consideration, 4,250 lb P_2O_5 would have been applied to only 98 acres, which is 250 lb P_2O_5 more than for the single field application rate. Moreover, yield potential and fertilizer P use-efficiency would be maximized. ■

Missouri

Phosphorus Fertilization Increases Annual Lespedeza Forage and Seed Yields

By Robert L. McGraw and Richard E. Joost

Field research in southwest Missouri on soils with low phosphorus (P) and medium potassium (K) fertility recorded annual lespedeza response to applied P but not K.

TWO SPECIES of annual lespedeza (Korean and striate) are grown in Missouri and throughout the southeastern U.S. for hay and in association with grasses for pasture. Annual lespedeza produces excellent quality, non-bloating forages during mid-summer . . . a time when forage supplies are often short.

The Missouri Fertilizer and Ag Lime Council funded research to determine the response of annual lespedeza to applied P and K at two sites at the Southwest Missouri Research Center near Mount Vernon. The soil at site 1 had an initial soil test level of 7 lb/A of available P and 248 lb/A of available K; site 2, 11 lb/A of P and 185 lb/A of K. These soil test values are typical for the region. The plots were limed to soil test recommendations prior to seeding. 'Marion' striate lespedeza and 'Summit' Korean lespedeza were spring seeded at 25 lb/A at both sites. Phosphorus at rates of 0, 40, 80, 120, and 160 lb/A P_2O_5 and K at rates of 0, 60, and 120 lb/A K_2O were applied in all possible combinations before seeding. Each plot was split. Forage yields were taken on one half in August and seed yields on the other half in October. Plots were allowed to reseed and no additional P or K was added the second year.

Results

Responses were similar for the two species at both sites both years so we combined data for discussion. Annual lespedeza did not respond to applied K. Plots fertilized with 60 or 120 lb/A K_2O produced forage and seed yields comparable to the controls with no added K. No interactions with applied P were noted. Applied P increased both lespedeza forage and seed yields. Without added P,

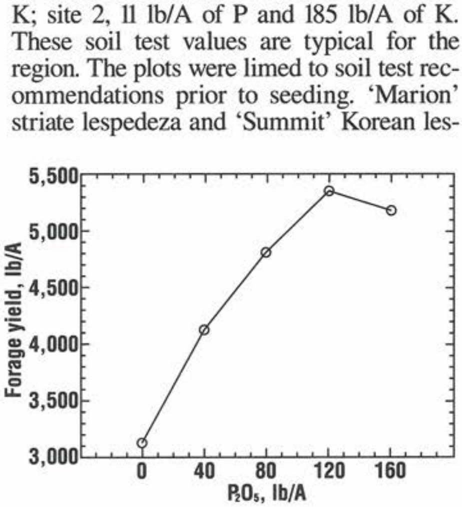

Figure 1. Applied P fertilizer increased herbage yield of annual lespedeza.

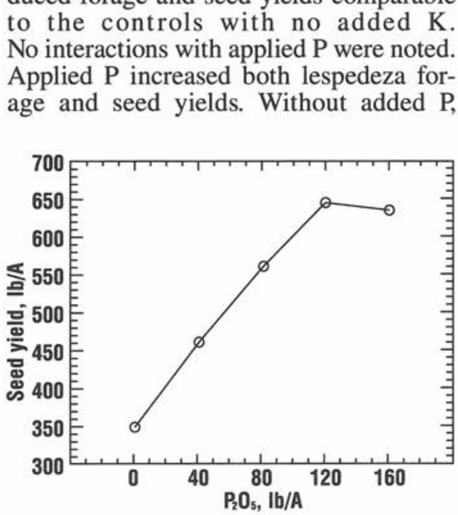

Figure 2. Applied P fertilizer increased seed yield of annual lespedeza.

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PHOSPHORUS fertility may be a key to establishing and maintaining annual lespedeza.

forage yields averaged 3,125 lb/A, shown in **Figure 1**. Yields increased 1,000 lb/A by application of 40 lb/A P_2O_5 and reached a maximum of 5,355 lb/A with application of 120 lb/A P_2O_5. Seed yields showed similar increases in response to applied P, indicated in **Figure 2**. Seed yields increased 110 lb/A with 40 lb/A P_2O_5 and reached a maximum of 635 lb/A at 120 lb/A P_2O_5.

Summary

Annual lespedeza did not respond to K fertilizer in this study, probably due to adequate (medium level) initial K fertility. Annual lespedeza responded to P up to 120 lb/A P_2O_5. Forage yields were increased by 1.1 ton/A and seed yields by 290 lb/A at the highest response rate.

The strong response to applied P indicates that adequate P is very important for successful production of annual lespedeza. Many soils in southwest Missouri and other areas where annual lespedeza is grown are known to have low P supplying capability. Problems associated with establishing and maintaining annual lespedeza may be due in part to poor P fertility.

Increased forage and seed yields from applied P were highly profitable. Figuring lespedeza hay at $65/ton, seed at $1.00/lb and P_2O_5 at 25 cents/lb, returns from increased forage yields would be more than double the investment in P and return from seed would increase by a net of $260. High rates of applied P would also have carry-over effects on following forage crops. ■

North Central Soil Fertility Conference Proceedings Available

PRESENTATIONS at the 1994 North Central Extension-Industry Soil Fertility Conference, held in St. Louis, MO, October 26-27, are available for interested individuals. The conference is an annual opportunity for agriculturalists from the North Central region of the U.S. and Canada to be updated on the latest developments in soil fertility research and education. The North Central region includes the states of North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Kentucky, Indiana, Michigan, Ohio and the province of Ontario.

Proceedings of the Conference include presentations on spatial variability of soil test phosphorus (P); using chlorophyll meters to improve nitrogen (N) use efficiency in corn and wheat; influence of seed-placed fertilizer on corn, soybean and sunflower emergence; soil nitrate test performance on medium and high yield potential soils; starter fertilizer effects on corn grown on previously flooded soils; flooded soil syndrome and P deficiencies; N management for no-till production systems; the role of soil fertility in reducing plant stress from root-feeding insects; survival of plant growth-enhancing root fungi after flooding and extended fallow; chemical and biological changes resulting from soil submergence; using grid soil sampling for precision and profit; the role of combine yield monitors in nutrient management, and other topics.

Copies of the 1994 Conference proceedings are available at a price of $15 from the Potash & Phosphate Institute, 2805 Claflin Road, Suite 200, Manhattan, KS 66502; phone 913-776-0273, fax 913-776-8347. A limited number of copies of proceedings of the 1993 Conference are also available at a price of $15. ■

Kansas

Managing Acid Soils for Optimum Wheat Production

By Ray E. Lamond and David A. Whitney

Kansas data emphasize the importance of liming acid soils for profitable wheat production. Banded phosphorus (P) fertilizer placed with the seed at planting is a viable short-term management alternative when liming is not possible.

ACID SOILS with accompanying high aluminum (Al) levels are reducing wheat yields in the heavy production regions of southcentral Kansas and northcentral Oklahoma. The thirteen counties in the South Central Kansas Crop Reporting District represent 2.5 to 3.0 million acres of wheat, much of which is used for a combination of grazing and grain production. The region is predominately continuous wheat with aggressive fertility management which includes additional nitrogen (N) applied for fall and winter grazing.

Over the years, continual use of ammoniacal N at rates to meet forage and grain production needs has gradually lowered soil pH levels. During the past 10 to 15 years, forage and grain yield responses to lime application have been demonstrated by Kansas and Oklahoma researchers. More than a third of the soil samples from the southcentral Kansas area tested by the KSU soil testing lab over the past four years had pHs of 5.5 or less.

Lime costs are substantial due to the fact that lime quarries are more than 100 miles away from much of the area. Because of high lime costs and reluctance of land owners to cost-share, producers are interested in alternatives to aglime. Kansas research has evaluated lime rates, P application, and varieties as management tools for wheat production on these acid, high Al soils.

A lime rate study was initiated in the fall of 1985 on a site in Kingman County that had an initial soil pH of 4.7 and a potassium chloride (KCl)-extractable Al level of 84 parts per million (ppm). Aglime was applied at rates of 3,000, 6,000, or 12,000 lb/A effective calcium carbonate (ECC). The 12,000 lb/A ECC rate was the full recommended rate to bring soil pH back to 6.8 based on the SMP buffer lime requirement test and neutralization of 2 million pounds of soil (about a 6 to 7 inch depth). Lime was applied in September and incorporated prior to seeding. Newton wheat, which is sensitive to Al, was used. The site was conventionally tilled during the four years of the trial with no additional lime applied. **Table 1** summarizes the effects of lime rate on wheat yields and soil pH and Al levels.

Table 1. Lime effects on wheat yields and soil pH and Al levels.

Lime rate, lb ECC/A	1986-1989 avg. wheat yield, bu/A	1989, 0-6 in. depth Soil/pH	Al, ppm
0	14	4.6	102
3,000	37	5.1	26
6,000	38	5.9	0
12,000	37	6.4	0

Kingman County, KS

Application of lime, regardless of rate, increased average yearly wheat yields by over 20 bu/A. Over the four years of this study, 3,000 and 6,000 lb/A rates of lime (ECC) performed just as well as the full rate in terms of yield response. However, four years after application, the 3,000 lb/A rate pH was 5.1 and KCl-extractable Al was 26, indicating a need to relime. The pH resulting from the application of the full rate of lime was 6.4 with no KCl-extractable Al. These data indicate that application of less than full recommended lime rates is effective, but more frequent reliming will be necessary.

Phosphatic fertilizer is known to react with soluble soil Al and could be used to

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LIME application is very effective on acid soils.

BANDED P (with seed) is effective in overcoming Al toxicity on Al-sensitive varieties when liming is not possible.

reduce Al toxicity. Wheat varieties are also known to differ in susceptibility to Al toxicity. A study was established to evaluate half and full recommended lime rates (0, 3,750, 7,500 lb ECC/A), P treatments (none, 40 lb P_2O_5/A broadcast, 40 lb P_2O_5/A banded with the seed), and two wheat varieties (Karl–sensitive to Al; 2163–tolerant to Al). The study site in Sedgwick County had an initial soil pH of 4.7 with 47 ppm KCl-extractable Al and a Bray-1 P level of 54 ppm.

Lime and broadcast P were applied and incorporated in late July, 1991, and wheat was seeded in September. Two consecutive wheat crops were evaluated with the broadcast and banded P applied each year. Conventional tillage operations were employed. Soil samples were taken after harvest of the second wheat crop in June, 1993.

The photos show the effect of liming on wheat growth, and the dramatic response of banding P on this acid, high Al soil where no lime had been applied. The response to P was possibly due largely to the banded P complexing Al out of the soil solution and reducing Al toxicity. **Table 2** summarizes the effects of liming, P, and varieties on wheat grain yields.

Table 2. Lime, P and variety effects on two-year average wheat grain yields.

Variety	Lime rate, lb ECC/A	Method of application and P_2O_5 rate, lb/A: None	40 Broadcast	40 Banded
		--- Wheat grain yield, bu/A ----		
Karl	0	38	42	54
	3,750	51	51	57
	7,500	49	49	55
2163	0	49	53	56
	3,750	58	57	60
	7,500	58	54	61

Sedgwick County, KS

Application of lime to this acid soil significantly increased wheat grain yields of both varieties when no P was applied. Even though 2163 is considered tolerant to Al toxicity, a 9 bu/A yield increase to lime was obtained, showing genetic tolerance cannot completely overcome the effects of acidity and Al toxicity. The 3,750 lb ECC/A rate (half of the full recommended rate) performed as well as the full 7,500 lb ECC/A rate in terms of increasing yields.

Banded P with the seed at planting was very effective in overcoming Al toxicity without lime. Broadcast P was not nearly as effective as banded P. The response to banded P was not likely a nutrient response because of the high (54 ppm) Bray-1 P soil test.

Table 3 summarizes lime effects on soil pH and Al levels two years after lime application on samples taken to a 6 inch depth. The data indicate that lime is effectively raising soil pH and reducing soluble Al levels. The use of less than the full recommended rate of lime is a viable short-term option, although reliming on a more frequent basis will be necessary. ■

Table 3. Lime effects on soil pH and Al.

Lime rate, lb ECC/A	Soil pH	KCl-Extractable Al, ppm
0	4.7	50
3,750	5.3	0
7,500	5.8	0

Initial soil pH 4.7, soluble Al 47 ppm.

Sedgwick County, KS

No-till Grain Sorghum Responds to Starter Nitrogen-Phosphorus Combinations

By W. B. Gordon and David A. Whitney

Kansas studies emphasize the importance of starter fertilizers containing nitrogen (N) and phosphorus (P) in no-till grain sorghum. Higher N relative to P in the starter resulted in greater crop response than conventional 1:3 ratios of $N:P_2O_5$.

MAINTAINING ground cover from crop residues to control soil erosion is an important factor in crop production in the central Great Plains. No-till production systems are effective in maintaining those surface residues. But, early-season plant growth and yield are often poorer in no-till than in conventional systems. The large amount of surface residues in no-till systems can reduce seed-zone temperatures and hamper plant nutrient uptake. However, starter fertilizers can place nutrients within the rooting zone of seedlings for improved nutrient availability, better uptake and improved early season growth.

Some experiments that have evaluated crop response to N-P starter fertilizers have demonstrated improved early growth and increased yield and attributed those responses to the P component of the combination. Other studies have indicated that N is the most critical element in the N-P starter fertilizer on soils not low in P.

Some grain sorghum producers in the Great Plains prefer to delay planting until mid-June in order to avoid drought and heat stress in July during the reproductive phase of crop development. However, late planting increases the risk of an early frost before the crop is mature. Use of starter fertilizer can hasten maturity and avoid late-season, low temperature damage. Planting sorghum early to produce heading prior to mid-season heat and moisture stress is hindered by sorghum's slow emergence and growth in cool soils. Starter fertilizer can be useful in improving early-season growth in cool soils.

Little information is available on the response of grain sorghum to $N\text{-}P_2O_5$ combinations (ratios) in starter fertilizers. This study was designed to evaluate no-till grain sorghum response to several $N\text{-}P_2O_5$ starter fertilizer combinations at two planting dates.

Kansas Study

This field experiment was conducted at the North-Central Kansas Experiment Field near Belleville, KS, on a Crete silt loam soil for three crop years, 1991-1993. Initial soil test values were high, 24 parts per million (ppm) Bray-1 P and 380 ppm exchangeable K. Treatments consisted of mid-May and late June planting dates and $N\text{-}P_2O_5$ liquid starter fertilizer combinations to supply 0, 10, 30 or 90 lb N/A with or without 30 lb P_2O_5/A. A surface broadcast treatment consisting of 90 lb N and 30 lb P_2O_5/A (no-starter check) was also included. Starter fertilizer treatments were knife-applied at planting 2 inches to the side and 2 inches below the seed. Immediately after planting, surface broadcast applications brought the total amount of nutrients applied to 90 lb N and 30 lb P_2O_5/A.

Results

No interactions between planting date and starter fertilizer combinations were noted, but earlier planting did signifi-

Dr. Gordon is Agronomist, North-Central Kansas Experiment Fields, Courtland, KS and Dr. Whitney is Agronomy Extension Leader, Kansas State University, Manhattan, KS.

Table 1. Planting date and starter fertilizer effects on 6-leaf stage dry matter and P uptake, days from emergence to mid-bloom, and yield of no-till grain sorghum.

Treatment, lb/A Starter N	P_2O_5	Yield, bu/A	Days to mid-bloom	-------- 6-leaf stage --------- Dry matter, lb/A	P Uptake, lb/A
10	30	91	65	587	2.2
30	30	101	59	677	2.6
90	30	101	59	701	2.7
90	0	87	66	591	2.0
30	0	87	66	575	2.0
0	30	88	67	580	2.0
90	30 Broadcast	83	66	556	2.0
Planting Date					
May		108	68	637	2.4
June		74	60	581	2.0

cantly increase yields. Starter responses were recorded for both the early and late planting dates.

Averaged over the three years, starters that supplied either 30 or 90 lb N/A with 30 lb P_2O_5/A (1:1 and 3:1 N:P_2O_5 ratios) both increased yields by 18 bu/A over the no starter check (**Table 1**). At current market prices, that response represents increased revenue of over $33/A. Application of 10 lb N/A with 30 lb P_2O_5/A (1:3 N:P_2O_5 ratio) also increased yields over the no starter check but was not as effective as the 1:1 or 3:1 ratios. Nitrogen or P applied alone did not result in any yield increase over the no starter check.

When compared to the check, the 1:1 and 3:1 N:P_2O_5 starter ratios shortened the period from emergence to mid-bloom by 7 days. None of the other starter combinations produced this affect.

Only the 1:1 and 3:1 N:P_2O_5 ratio treatments significantly increased early-season dry matter production and P uptake (6-leaf stage) compared to the no starter check.

Summary

Use of starter fertilizer significantly improved early-season growth, P uptake and yield of early and late-planted no-till grain sorghum even when soil test P was adequate. However, the traditional N:P_2O_5 ratio of 1:3 (10 lb N and 30 lb P_2O_5/A) was not as effective as a 1:1 (30 lb N and 30 lb P_2O_5/A) or a 3:1 (90 lb N and 30 lb P_2O_5/A) ratio. The 1:1 and 3:1 N:P_2O_5 ratio starters increased grain yields 22 percent over the no starter check. This study emphasizes the importance of starter fertilizers with higher N:P_2O_5 ratios in no-till sorghum production. ■

NO-TILL grain sorghum responses to starter N and P are dramatic. Plants on the left received high N:P_2O_5 ratio starter applications which enhanced both early growth and grain yields.

Texas

Fertilizer Scheduling Improves Yields and Quality, Plus Water and Nutrient Use Efficiency of Coastal Bermudagrass

By J.L. Sanders, J.N. Pratt, H.D. Pennington and D.H. Bade

First year data from a Texas study indicate that fertilizer application for Coastal bermudagrass two weeks prior to each harvest can significantly increase yield and forage quality. This concept needs further study at other locations for additional confirmation. Based on these results, this management technique can substantially improve farmer profits without increasing costs.

MORE TONNAGE of Coastal bermudagrass is harvested for hay in the Southern U.S. than any other warm season perennial grass cultivar. Coastal is a deep rooted, drought tolerant, high-yielding bermudagrass hybrid.

In a majority of hay meadows, growers harvest 2 to 4 cuttings annually on 28-day intervals for seasonal harvests of 3 to 5 tons per acre. Most soil testing laboratories and forage professionals recommend applying nitrogen (N) at about 50 lb/A plus other nutrients for each ton of hay to be harvested. Normal application is about 100 lb N/A in the spring, followed by the remainder in equal increments immediately after each harvest. In addition to N, bermudagrass also needs significant amounts of potassium (K), as well as phosphorus (P), sulfur (S), magnesium (Mg), copper (Cu), manganese (Mn), zinc (Zn) and boron (B).

Research, Extension and industry forage workers report that one ton of dry matter can be produced from about 3 inches of seasonal rainfall, if adequate nutrients are available. Thus, a potential 4 tons/A yield would result from 8 to 12 inches of rainfall when nutrient supply and other conditions are favorable.

A study was initiated to compare the conventional method of applying fertilizer immediately after harvesting with a fertilize-before-the-harvest application 2 weeks before harvest in a 28-day harvest cycle.

An established Coastal bermudagrass meadow on a Lufkin fine sandy loam soil was the test site. Soil pH was 6.4. A blended fertilizer with the analysis of 18N-5 P_2O_5-13K_2O-11S-2Mg-0.05Cu-0.1 Mn-0.1 Zn-0.02B was used throughout the season. Potassium was also applied in the previous fall at a rate of 180 lb K_2O/A.

Treatments included: (1) the conventional method of applying fertilizer at spring green-up, followed by topdress application immediately after each harvest, and (2) applying fertilizer at spring green-up followed by topdress fertilization 14 days before (FB) each 28-day planned harvest. Both treatments received equal amounts of nutrients and were harvested on the same dates. Dates of application and harvest for the conventional and the before-harvest application treatments are reported in **Table 1**.

Yield, percent protein and protein produced per acre are shown for the four harvest dates in **Table 2**. Seasonal yields of the treatment fertilized before harvest (FB) were 1,706 lb/A or 17.6 percent

Dr. Sanders is Director of Agronomic Services, American Plant Food Corp., Galena Park, TX. Dr. Pratt is Professor and Extension Agronomy Specialist Emeritus; Dr. Pennington is Retired Extension Soil Chemist; and Dr. Bade is Professor and Extension Forage Specialist, Texas A&M University, College Station, TX.

CONVENTIONAL fertilization effects are shown on first-cut Coastal bermudagrass.

BERMUDAGRASS fertilized two weeks before cutting . . . notice that plant color is deeper green and leaf density is greater.

Table 1. Fertilizer application and harvest dates.

Fertilizer application dates: Conventional	Fertilizer application dates: Fertilized before harvest	Harvest date
May 25	May 25 June 9	June 22
June 27	July 8	July 21
July 25	Aug. 5	Aug. 31
Sept. 7		October 14

greater than the conventional treatment, with second and fourth harvest yields 28 percent greater. Protein production was increased by 454 lb/A, 37 percent more than the conventional treatment.

The effects of fertilizer scheduling on water use efficiency (WUE) are shown in **Table 3**. Average seasonal water use efficiency was 639 lb hay per inch of rainfall in the conventional treatment compared to 752 lb/inch in the FB treatment, a 17.7 percent increase. During the driest period, rainfall was only 0.63 inches in the 28 days prior to the July 21 harvest. Water use efficiency was improved 28 percent by fertilizing before harvest.

The effects of fertilizer scheduling on apparent nutrient use efficiencies are

(continued on page 19)

Table 2. Effects of fertilizer scheduling on Coastal bermudagrass yield, protein content and protein production.

	Conventional			Fertilized before harvest		
Harvest date	Yield, lb/A	Crude protein, %	Protein, lb/A	Yield, lb/A	Crude protein, %	Protein, lb/A
June 22	3,942	12.1	475	4,790	15.6	748
July 21	1,309	8.4	109	1,681	8.9	150
Aug. 31	2,709	14.1	382	2,700	16.0	433
Oct. 14	1,753	15.1	264	2,247	15.7	353
Total	9,713		1,230	11,419		1,684

Table 3. Effects of fertilizer scheduling on water use efficiency of Coastal bermudagrass.

Harvest period	Rainfall accumulation, in/harvest	Water use efficiency, lb/in: Conventional fertilization	Water use efficiency, lb/in: Fertilized before harvest
May 25-June 22	4.12	957	1,163
June 22-July 21	0.63	2,078	2,668
July 21-Aug. 31	5.02	540	538
Aug. 31-Oct. 14	5.42	323	415
Total	15.19	–	–
Average	–	639	752

Three Graduate Students Receive "J. Fielding Reed PPI Fellowships"

THREE outstanding graduate students have been announced as the 1995 winners of the **"J. Fielding Reed PPI Fellowships"** by the Potash & Phosphate Institute (PPI). Grants of $2,000 each are presented to the individuals. All are candidates for either the Master of Science (M.S.) or the Doctor of Philosophy (Ph.D.) degree in soil fertility and related sciences.

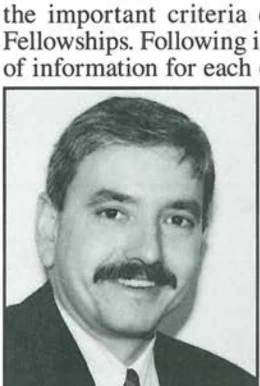
The 1995 recipients were chosen from over 30 applicants who sought the Fellowships. The three are:

- **Jürg M. Blumenthal**, University of Minnesota, St. Paul
- **Kevin A. Cook**, Brigham Young University, Provo, UT
- **Mark A. Fairchild**, University of Kentucky, Lexington

Funding for the Fellowships is provided through support of potash and phosphate producers who are member companies of PPI.

"Each year, we have the privilege of presenting this recognition. All of the applicants for the Fellowships have excellent credentials," noted Dr. David W. Dibb, President, PPI. "The individuals selected and their educational institutions can take pride in the level of achievement represented."

Scholastic record, excellence in original research, and leadership are among the important criteria evaluated for the Fellowships. Following is a brief summary of information for each of the winners.



Jürg M. Blumenthal

Jürg M. Blumenthal is a native of Surcasti, Switzerland. He received both his B.S. and M.S. degrees from the Federal Institute of Technology, Zürich, Switzerland. He is currently pursuing his Ph.D. degree at the University of Minnesota. The title of his dissertation is "Nitrogen Economy of Alfalfa." He believes his research will characterize germplasm efficiency in remediating nitrate-N contaminated soils, broaden knowledge of the interdependence of symbiotic N fixation and mineral N nutrition and contribute to the sustainability of agricultural systems. He plans a career in soil fertility and plant nutrition research and Extension, at either a public or private institution.

Kevin A. Cook

Kevin A. Cook was born in Provo, UT, and raised on a farm in Ririe, ID. He received his B.S. degree from Brigham Young University (BYU). He is presently studying for his M.S. degree, also at BYU. The title of his thesis is, "Assessment of the Potential Use of Iron Reductase Isozymes as an Indicator of Iron Deficiency Chlorosis Resistance in Soybeans." One of his professors said, "Kevin is as fine a student as has graduated from our department." Another described him as " . . . perhaps one of the best all-around students I have advised in 30 years." Mr. Cook plans a career in research upon completion of his Ph.D. degree at Iowa State University.

Mark A. Fairchild

Mark A. Fairchild is currently working toward a Ph.D. degree at the University of Kentucky. He earned both the B.S. and M.S. degrees from Kansas State University. Mr. Fairchild is a native of Tribune, KS. The tentative title of his dissertation is "Denitrification Dynamics in Fragipan Soils of Kentucky." The purpose of his research is to see how manure and cover crops influence denitrification above a fragipan under controlled conditions. After receiving his Ph.D. degree, Mr. Fairchild plans to work in a less developed country where he can teach better farming methods to the people . . . including better use of fertilizers and environmentally sound practices. He would also like to conduct research to support his teaching. ■

Fertilizer Scheduling . . . from page 17

shown in **Table 4**. Both N and K showed the greatest increases from fertilizing before the harvest (11 percent and 10 percent, respectively). Phosphorus use efficiency increased slightly, but S showed no response and Mg use efficiency decreased by 5 percent.

Summary

For the farmer/rancher, the advantages of fertilizing before harvest compared to the conventional method include:

- Improved forage quality.
- Higher forage crude protein content (greater than 15 percent throughout the season except for the drought harvest on July 21).
- Increased seasonal yield (17.6 percent).
- Increased protein production/A (37 percent).
- Increased nutrient use efficiency.
- Improved water use efficiency (over 17 percent).

Table 4. Effects of fertilizer scheduling on apparent nutrient use efficiencies.

	Seasonal nutrient use efficiency– lb/A harvested/lb/A applied				
	N	P_2O_5	K_2O	S	Mg
Total amt. applied, lb/A	360	100	440	220	40
Conventional fertilization	0.63	0.47	0.55	0.12	0.54
Fertilized before harvest	0.74	0.49	0.65	0.12	0.49

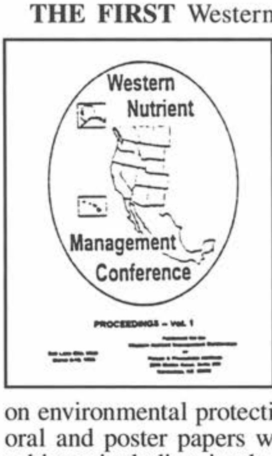
Advantages of this system for fertilizer dealers include:

- Spreader tracks visible and easily discerned by applicator driver, aiding in achieving even spread pattern.
- Fields can be fertilized without delays caused by hay baling and removal.

The bottom line is that timing fertilizer applications before harvest can boost Coastal bermudagrass yields, quality and profits. ■

Western Nutrient Management Conference Proceedings Available

THE FIRST Western Nutrient Management Conference was held in Salt Lake City, UT, March 9-10, 1995. This conference provided a forum for discussion of nutrient management for all types of crop production with emphasis on environmental protection. A total of 33 oral and poster papers were presented on subjects including implementing nitrogen fertilizer best management practices, potassium fertility guidelines for California crops, chloride nutrition of wheat, predicting wheat protein increases from topdressed N, and fertility management for high density apple orchards.



The United States, Canada and Mexico were represented by presentations at the Conference. States and provinces covered by the Conference included Saskatchewan, Alberta, British Columbia, Alaska, Washington, Idaho, Montana, Oregon, Wyoming, California, Nevada, Utah, Colorado, New Mexico, Arizona, Hawaii and northern Mexico.

Copies of the proceedings are available at a price of $15 from the Potash & Phosphate Institute, 2805 Claflin Road, Suite 200, Manhattan, KS 66502; phone 913-776-0273, fax 913-776-8347. ■

Cotton Response to Foliar Application of Potassium Compounds at Different pH Levels

By M. A. Chang and D. M. Oosterhuis

The pH of potassium (K) solutions used in foliar fertilization of cotton has a major effect on leaf burn, leaf expansion, K uptake by leaves, movement to the bolls, and lint yield. Leaf burn was decreased, while K concentration of plant organs and lint yield were increased at neutral to acidic pHs.

WIDESPREAD K deficiencies have been reported across the U.S. Cotton Belt. These deficiencies are associated with the introduction of early-maturing, short-season cultivars with higher fruit loads. Deficiencies can be corrected by soil or foliar applications of K. Soil application at mid-to-late season may be less beneficial because of inefficient K uptake by the root system during boll development.

Foliar applications have the advantage of rapid absorption into the leaf and efficient movement to the developing bolls. However, the response to foliar fertilization with K has been inconsistent. Research in Tennessee has indicated that lowering the pH of foliar-applied potassium nitrate (KNO_3) solutions increases K absorption by the leaf. Our study examined the effect of lowering solution pHs of various commercial K compounds on foliar burn, leaf absorption, and accumulation of K in the boll.

The field study was conducted at the Arkansas Agricultural Experiment Station, Fayetteville, in 1994 on a Captina silt loam soil with an initial soil test level of 231 lb K/A. Treatments and their pH values (**Table 1**) included a control and eight foliar applied K compounds: KNO_3, potassium chloride (KCl), potassium sulfate (K_2SO_4), potassium thiosulfate ($K_2S_2O_3$), potassium carbonate (K_2CO_3), potassium hydroxide (KOH), potassium bicarbonate ($KHCO_3$), and potassium acetate (CH_3COOK). The treatments were applied four times with a carbon dioxide - pressured backpack sprayer at 4.4 lb K_2O/A at weekly intervals starting two weeks after appearance of the first white flower.

Table 1. Standard (S) and adjusted (A) pHs of K solutions prepared to deliver 4.4 lb K_2O/A in 10 gallons of water.

	pH	
K compound	Standard (S)	Adjusted (A)
KNO_3	9.4	4.0
KCl	9.4	4.0
K_2SO_4	9.9	4.0
$K_2S_2O_3$	6.8	4.0
K_2CO_3	11.6	7.0
KOH	13.6	7.0
$KHCO_3$	8.2	–[1]
CH_3COOK	8.3	–[1]

[1]Not adjusted due to excessive volume of buffer needed.

All K compounds were tested at the standard pH (S) of the K compound when mixed with water at an equivalent rate of 4.4 lb K_2O/A in 10 gallons of water. Potassium nitrate, KCl, K_2SO_4 and $K_2S_2O_3$ were also tested at a lower pH of 4, produced by adjusting the pH (A) using Xtra Strength buffer XS (Helena Chemical Company). The pHs of K_2CO_3 and KOH were adjusted to 7, and $KHCO_3$ and CH_3COOK were tested only at their standard pH values due to the excessive volume of buffer needed to lower the pH.

Visual observations of leaf burn were recorded 24 hours after foliar treatment applications. Visual symptoms of

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phytotoxicity were rated from zero (no burn) to 100 percent (full canopy burn). Forty-eight hours after foliar applications, samples of five fully expanded upper canopy leaves along with their petioles and five developing bolls, with diameters less than an inch, were collected. Petioles were immediately excised from the leaf blades. The leaf area of each treatment was recorded to observe the treatment effect on leaf growth. Leaf, petiole and boll K concentrations were analyzed to determine treatment effects on the uptake of K by leaves and K movement to the bolls.

At standard pH, K_2SO_4 did not cause any leaf burn, KNO_3 caused <0.5 percent, and KCl 3.5 percent. In contrast, substantial leaf burn was caused by KOH (39.2 percent), K_2CO_3 (36.3 percent), $K_2S_20_3$ (32.5 percent), $KHCO_3$ (28.3 percent) and CH_3COOK (22.1 percent).

When the pHs of KOH and K_2CO_3 were lowered to 7, the phytotoxic effects were decreased significantly to 3.75 percent and 3.25 percent respectively. As a result, the leaf burning effects of KOH and K_2CO_3 were not significantly different from the leaf burning effects of KCl, KNO_3, K_2SO_4 and the untreated control. When the pH of $K_2S_20_3$ was decreased, its phytotoxicity was also significantly decreased from 32.5 to 26.25 percent.

These results show that K solution pH has an important role in correcting phytotoxic effects of foliar K applications. Leaf burn can disrupt cell membrane integrity and photosynthesis, resulting in decreased carbon fixation and dry matter accumulation, lower boll weights and decreased yield (data not presented).

The leaf area of the top five leaves was considerably reduced from 390 cm^2 in the untreated control to 304, 318 and 325 cm^2 in the KOH, K_2CO_3 and $K_2S_20_3$ treatments, respectively, at standard solution pH values. That means that foliar treatments with high phytotoxic effects also reduced the growth of upper canopy leaves which would further contribute to decreased production of photosynthates necessary for boll development and high yields.

Large quantities of Xtra Strength buffer were required to adjust the pH values of K_2CO_3, KOH, $KHCO_3$, and CH_3COOK. The K_2CO_3 solution required about 15 percent volume/volume (v/v) of the buffer to adjust its pH value to 7. The KOH and $KHCO_3$ solutions required about 25 percent v/v of the buffer to adjust their pH values to 7. The buffered solution of $KHCO_3$ was not stable. Its pH increased to 7.4 after 2 hours of storage at 77°F (25.0°C). The CH_3COOK solution required about 52 percent v/v of the buffer to adjust its pH to 4, which also was not stable and increased to 4.3 after 2 hours of storage. Therefore, $KHCO_3$ and CH_3COOK were applied only at their standard pH levels.

Table 2. Potassium concentration (as percent above the untreated control) in cotton leaves, petioles and bolls 48 hours after the fourth foliar application of various K compounds with standard or adjusted solution pH.

K compound	K concentration, % above untreated control					
	Leaves		Petioles		Bolls	
	Solution pH					
	Standard	Adjusted	Standard	Adjusted	Standard	Adjusted
KNO_3	38.8	31.7	28.2	18.4	10.1	3.9
KCl	69.4	75.5	46.6	59.8	11.8	11.2
K_2SO_4	19.5	23.4	16.7	22.5	3.2	0.0
$K_2S_20_3$	86.2	92.3	62.8	53.4	11.3	13.4
K_2CO_3	143.0	121.7	68.0	64.0	12.0	35.8
KOH	182.9	134.0	115.0	82.4	21.1	52.8
$KHCO_3$	178.6	–[1]	82.3	–	18.9	–
CH_3COOK	91.8	–	50.7	–	10.0	–

[1] Not adjusted due to excessive volume of buffer needed.

Table 2 shows that K treatment increased K concentration in the leaves and petioles while lowering the pH had no significant effect. The largest increases in leaf K were caused by KOH, $KHCO_3$, and K_2CO_3, followed by CH_3COOK, $K_2S_20_3$ and KCl treatments at their standard as well as adjusted pH levels. Potassium nitrate and K_2SO_4 showed the lowest absorption compared to other K compounds.

All foliar-applied K treatments increased boll K concentration, except for K_2SO_4 adjusted to pH 4. Lowering pH of KOH and K_2CO_3 dramatically increased the K accumulation in the boll by 53 percent and 36 percent, respectively, compared to their standard pH values. These results indicate that when leaf burn was corrected by adjusting the pH of these K solutions, the movement of K from leaves to the boll sink was more efficient.

Lowering solution pH increased lint yield compared to the standard pH treatments for KNO_3, K_2SO_4, $K_2S_20_3$ and KOH, **Figure 1**. Lowering the solution pH had no effect on yield for KCl or K_2CO_3. The largest yield increases from lowering solution pH occurred with KOH and K_2SO_4.

Summary

Foliar applications of K_2SO_4, KNO_3 and KCl caused either none or minimal leaf burn at high or low pH. The highest leaf burn was caused by the applications of KOH, K_2CO_3, $K_2S_20_3$, $KHCO_3$ and CH_3COOK when applied at their standard pH values. When pHs of KOH and K_2CO_3 were adjusted to 7, leaf burn was reduced to about 3.5 percent. The growth of the upper canopy was also severely affected by the phytotoxic effects of KOH, K_2CO_3 and $K_2S_20_3$ when applied at their standard solutions pH values. Lowering the pH increased the lint yield for KNO_3, K_2SO_4, $K_2S_20_3$, and KOH, but not for KCl or K_2CO_3.

The pH of the foliar fertilizer solution has an important role in altering phytotoxic effects as well as on absorption and translocation of K to the bolls. Further research is needed to evaluate the optimum pH for maximum foliar absorption and movement to the bolls of various K sources. There is also a need to explore suitable buffer solutions for adjusting the pH of the K solutions because a specific buffer solution may not be ideally suitable for all nutrient solutions. ■

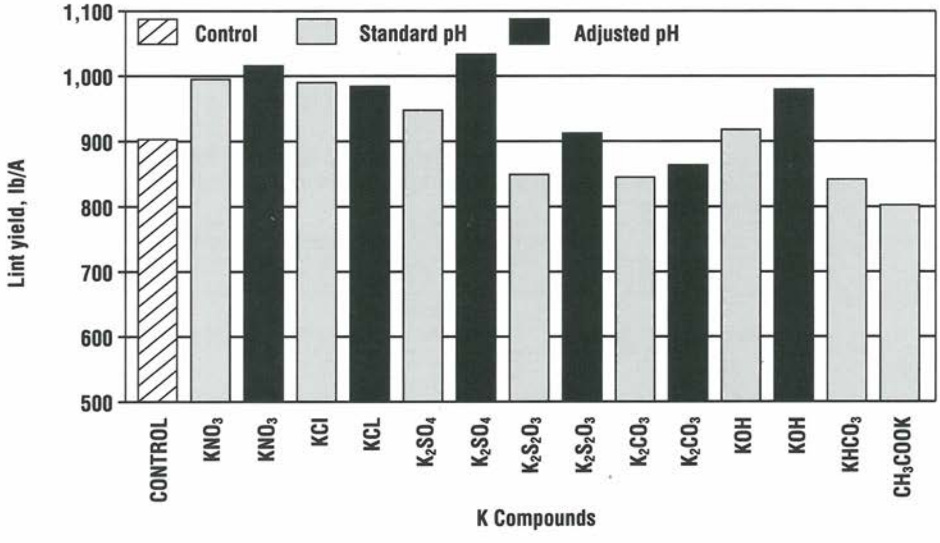

Figure 1. Cotton lint yields were improved by adjusting solution pH in foliar application of several K sources.

Conversion Factors for Metric and U.S. Units

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1, multiply by
		Length	
0.621	kilometer, km	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
0.394	centimeter, cm	inch, in	2.54
		Area	
0.386	kilometer^2, km^2	mile^2, mi^2	2.590
247.1	kilometer^2, km^2	acre, acre	0.00405
2.471	hectare, ha	acre, acre	0.405
		Volume	
0.00973	cubic meter, m^3	acre-inch	102.8
3.532	hectoliter, hl	cubic foot, ft^3	0.2832
2.838	hectoliter, hl	bushel, bu	0.352
0.0284	liter, 1	bushel, bu	35.24
1.057	liter, 1	quart (liquid), qt.	0.946
		Mass	
1.102	tonne (metric)	ton (short)	0.9072
2.205	quintal, q	hundredweight, cwt (short)	0.454
2.205	kilogram, kg	pound, lb	0.454
0.035	gram, g	ounce (avdp), oz	28.35
		Yield or Rate	
0.446	tonne (metric)/hectare	ton (short)/acre	2.240
0.891	kg/ha	lb/acre	1.12
0.891	quintal/hectare	hundredweight/acre	1.12
1.15	hectoliter/hectare, hl/ha	bu/acre	0.87
		Temperature	
(1.8 x C) + 32	Celsius, C	Fahrenheit, F	0.56 x (F-32)
	-17.8°	0°F	
	0°C	32°F	
	20°C	68°F	
	100°C	212°F	

Metric Prefix Definitions

mega	1,000,000	deca	10	centi	0.01
kilo	1,000	basic metric unit	1	milli	0.001
hecto	100	deci	0.1	micro	0.000001

To convert U.S. crop yields from bushels per acre (bu/A) to metrics:

Corn — bu/A x 0.063 = tonnes/ha
Soybeans — bu/A x 0.067 = tonnes/ha
Wheat — bu/A x 0.067 = tonnes/ha
Grain Sorghum — bu/A x 0.056 = tonnes/ha

India

Consequences of Potassium Depletion under Intensive Cropping

By Ch. Srinivasa Rao and M.S. Khera

Consequences of potassium (K) depletion were demonstrated with sudan grass in this study. Rebuilding fertility of K-depleted soils in India may require even higher rates due to the negative effects of imbalanced nutrient use.

POTASSIUM content of India's soils has traditionally been considered as adequate. In recent years, however, there has been a growing awareness of the importance of K in crop production.

Under continuous cropping, fertilizer-responsive varieties with improved management practices can remove more than 400 kg K/ha/year. It is estimated that a 6.1 t/ha grain crop in a rice-wheat system will remove 150 kg K/year from soil. In the absence of fertilizer K . . . or with low levels of applied K . . . continuous cropping will result in the depletion of soil K reserves. Even soils which are initially well supplied with K will become deficient under such management.

Recent increases in prices of K fertilizers have added to the existing problem of exploitation of soil K under continuous cropping without fertilizer K. Consumption of K fertilizers has decreased drastically. For the country as a whole, the drop in K fertilizer consumption during 1992-93 was 46.7 percent compared to 1991-92, leading to an imbalanced fertilizer consumption ratio of 12.7:3.9:1.0 ($N:P_2O_5:K_2O$), far different from the 4:2:1 which is considered a balanced ratio. The present study was initiated to demonstrate the possible consequences of soil K depletion under intensive cropping.

Experimental

Eight representative surface (0-15 cm) samples of illitic alluvial soils from intensively cultivated fields and of varying K contents were collected. Samples were taken from farms adjoining the National Capital Region, Delhi. Soils were sandy to loamy sand in texture, alkaline in reaction (pH 8.1 to 9.0), with available K contents of 3.5 to 17.4 mg K_2O/g soil.

Soils were depleted of K by growing sudan grass (60 plants/pot) in 3 kg of soil by providing all essential nutrients except K. Seven harvests were taken at 35 day intervals (total of 245 days). After the third harvest, soils were processed and

Table 1. Average K uptake values in K-depletion experiments.

Soil Series	K uptake by harvest, mg/100g soil 1	2	3	4	5	6	7	Total K uptake, mg/100g soil
1–Hamidpur	19.22	10.63	3.94	4.13	2.63	2.10	1.84	44.49
2–Hisar	19.84	11.31	4.06	4.91	3.43	2.26	1.92	47.73
3–Kakra	15.12	9.91	3.92	3.98	2.40	1.96	0.98	38.27
4–Thaska	18.12	10.02	3.89	3.98	2.52	1.97	1.02	41.52
5–Manesar	17.27	9.97	2.68	3.27	2.11	1.86	0.97	38.13
6–Khoh	14.86	7.94	3.66	3.82	2.33	1.85	0.99	34.45
7–Palam	8.74	5.6	1.99	2.01	1.42	0.94	0.45	21.15
8–Mehrauli	17.94	10.8	4.04	4.43	2.94	1.90	1.68	43.77
Mean	16.39	9.52	3.52	3.82	2.47	1.86	1.23	38.81

Dr. Rao is Scientist, Indian Institute of Soil Science, Bhopal. Dr. Khera is retired Head, Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi.

fresh sudan grass seeds were sown. At each harvest, plant samples were analyzed for K uptake. Soils were analyzed for exchangeable K.

Results

Potassium uptake. Intensive cropping in the absence of fertilizer K reduced K uptake drastically after the first harvest (**Table 1**). Significant reductions continued up to the third harvest; thereafter, the rate of decrease was low. In the fourth harvest, a small increase in K uptake was observed, probably because of the greater ability of the resown crop to extract non-exchangeable K from soil. Potassium uptake was higher in soils rich in initial K (Hisar and Hamidpur) compared to the poor K soil (Palam).

Table 2. Mean dry matter yield of sudan grass in seven harvests.

Harvest number						
1	2	3	4	5	6	7
0.87	0.62	0.34	0.42	0.32	0.26	0.21
Dry matter yield, g/100g soil						

Crop yield. Dry matter yield in the third harvest was less than half that of the first harvest. In the fourth harvest, there was a slight increase in dry matter yield because it was a resown crop (**Table 2**). Yields in subsequent harvests were reduced to one-third of the first harvest. Such drastic yield reductions might be due in part to low photosynthetic efficiency, impaired aeration and various physiological disorders in the absence of sufficient amounts of available K. Varying yield reductions were observed among soils. High K (Hisar, Mehrauli and Hamidpur) soils maintained relatively higher yield levels up to the seventh harvest followed by medium K soils (Kakra, Thaska, Manesar and Khoh) which maintained more or less higher yields up to the sixth harvest. In the seventh crop harvest, yields on medium K soils fell below the high K soils. Lowest yields, even in the first harvest, were recorded on the low K (Palam) soil. Yield in the first harvest from this soil was comparable with yield of the fourth harvest of the high K soils.

Dependence on reserve K. The contribution of non-exchangeable K to total K uptake in 245 days of cropping was in the order of 73.2 to 93.9 percent (**Table 3**). The share of non-exchangeable K increased with cropping time. The contribution of non-exchangeable K was at its maximum when exchangeable K in soils was at its minimum. Contributions of non-exchangeable and available K were inversely related. That is, high K soils had the lower contribution from non-exchangeable K, whereas in the poor K soil, most K uptake was from non-exchangeable K reserves (**Figure 1**).

Fertilizer K requirement per unit increase in available K. Fixation studies before and after K depletion of test soils (**Table 3**) reveal that unit fertilizer K requirement per unit increase in available K was substantially increased with K depletion. All soils except Palam required around 1.2 units

Table 3. Potassium taken up from non-exchangeable sources and units of fertilizer K required per unit increase in available soil K.

Soil series	Total K uptake in 7 harvests, mg/100g soil	K taken up from non-exchangeable sources: mg K/100g soil	K taken up from non-exchangeable sources: % share of total uptake	Unit fertilizer K rate to increase soil test level by one unit: Before K depletion	Unit fertilizer K rate to increase soil test level by one unit: After K depletion
1–Hamidpur	44.5	32.58	73.2	1.15	3.03
2–Hisar	47.7	36.83	77.2	1.11	2.56
3–Kakra	38.1	32.19	84.1	1.18	2.56
4–Thaska	41.5	31.73	76.4	1.27	2.27
5–Manesar	38.1	31.72	83.2	1.37	2.86
5–Khoh	34.5	27.82	80.8	1.27	2.78
7–Palam	21.2	19.85	93.9	3.85	5.26
8–Mehrauli	43.8	34.23	78.3	1.27	2.63

(continued on page 27)

Argentina

Effects of Phosphorus Placement for Corn with and without Irrigation

By Hugo Fontanetto and Nestor Darwich

Research in Buenos Aires Province found that corn yield differences due to placement methods were associated with P concentrations in the plant and number of kernels per ear.

SOILS in southeast Buenos Aires Province have a generalized deficiency of available phosphorus (P). Responses to P applications have been variable. Nevertheless, it is well known that the efficiency of P fertilizers depends on the method of application (placement) as well as the level of soil P availability.

A field experiment was conducted in the EEA Balcarce-INTA during the 1987-88 season to determine the effects of different methods of P placement to the soil under two water regimes. The absorption of P by corn plants and its influence on grain yield were evaluated.

A single cross hybrid (SPS 240) was planted at a density of 80,000 plants/ha on a clay loam soil (Typic Arguidoll) with 9.5 parts per million (ppm) of available P.

Four P treatments and two water regimes were arranged in an experimental design which allows direct comparisons. The main plot treatments were: without irrigation (SR) and with irrigation (CR), to maintain 60 percent of field capacity.

Subplots with the different methods of P application were: 1) control . . . no P added, 2) P added beside the seed, 3) P applied in narrow bands (5 cm) at a depth of 20 cm and 4) P applied in wide bands (35 cm) at a depth of 20 cm. The P (P_2O_5) rate applied was 47 kg/ha.

The availability of soil P at two times of the growing season (planting and R1:silking) in the subplots under the different treatments are shown in **Figure 1**. Irrigation did not change the availability of soil P.

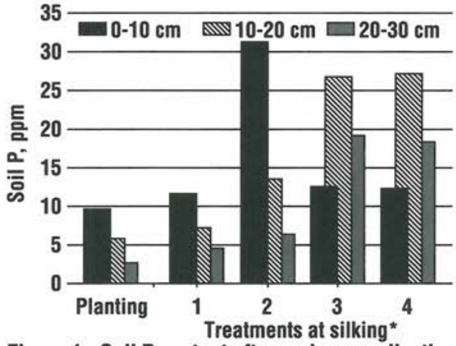

Figure 1. Soil P content after various application methods. (Argentina)

***1 = Control (No P), 2 = P beside the seed, 3 = P in narrow bands and 4 = P in wide bands.**

Figure 1 also shows that the lowest levels of available P occurred during the season when no P was applied. Application beside the seed resulted in the highest available P levels in the top 10 cm of soil. Between this depth and 30 cm, the highest contents were found with deep applications.

These results show that the different methods of P placement are effective in raising soil P levels according to the zone of application, and that the movement of P is limited since it stayed in the incorporation areas. Phosphorus distribution in the top 15 cm of profile remained uniform after several annual applications.

Grain yield was significantly affected by the different methods of P placement

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Yield differences due to placement methods were associated with P concentrations in the plant and number of kernels per ear.

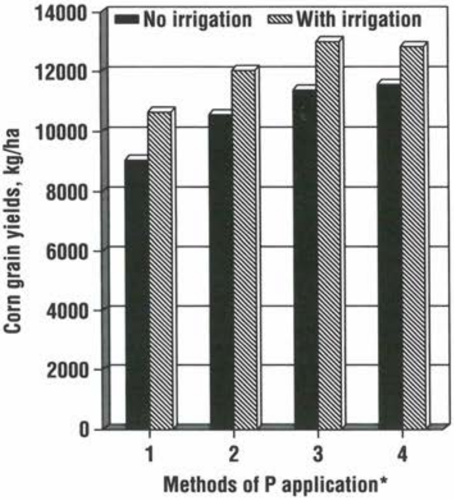

Figure 2. Corn grain yields, with and without irrigation and P addition. (Argentina)

***1 = Control (No P), 2 = P beside the seed, 3 = P in narrow bands and 4 = P in wide bands.**

and by supplemental irrigation, but no significant interaction was found amongst them. Irrigation produced higher yields than without irrigation (12,190 vs. 10,700 kg/ha). Yield was highest when P was banded in either wide or narrow bands (**Figure 2**).

Conclusion

This study clearly shows that the method and depth of P incorporation affected fertilizer use efficiency and that the best yields occurred with greater distribution of P applied in the top 30 cm of the soil profile. This better distribution allowed a higher absorption of P, higher P contents in the plant, improved crop growth and higher grain yields.

Supplemental irrigation resulted in even better P absorption by the corn plants, causing higher grain yields than in plots without irrigation.

Neither soil P nor moisture deficiencies were severe enough to trigger a positive interaction between P placement and supplemental irrigation.

Under the conditions of southeast Buenos Aires Province, it is possible to obtain yield responses with deeper P applications, in soils with moderate contents of available P and in years with moisture deficits, especially in the months of January and February. ■

(Potassium Depletion . . . from page 25)

of fertilizer K per unit increase in available K before K depletion. After K depletion, the requirement rose to 2.5 to 3 units. The previously K depleted (Palam) soil required 3.85 units, even before K depletion and 5.26 with K depletion. Therefore, if present-day imbalanced fertilizer consumption continues . . . without K or with little K fertilizer . . . a situation will arise where there will be a need to increase K fertilizer rates by five to six times over recommended rates to obtain optimum soil K levels.

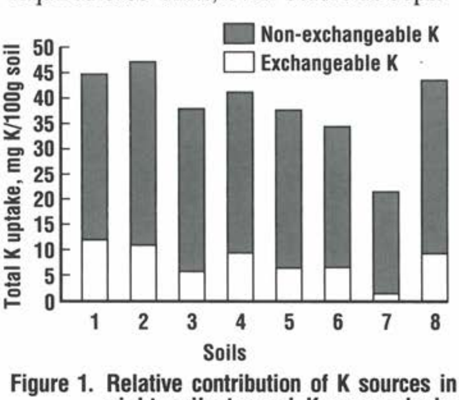

Figure 1. Relative contribution of K sources in eight soils toward K removals by seven cuts of sudan grass.

Conclusion

Our study clearly demonstrates the negative consequences of depleting soil K with intensive cropping without adequate K fertilization. Until potash prices stabilize in India, a majority of farmers will not purchase K fertilizers to feed K-starved soils. Depletion of soil K represents a deterioration of soil fertility and a loss in productivity. Infertile soils cannot support good crops and fulfill agricultural production targets which are being set by planners in order to feed the increasing population of India. ■

Maximizing Yield of Boro Rice Through Integrated Nutrient Management

By M.Q. Haque, M.I. Ali, G.K.M.M. Rahman, M.H. Rahman and A.K.M. Habibullah

Research shows potential of greatly increasing rice yields in Bangladesh if nutrient management and other improved production practices are adopted.

THE Bangladesh economy is based on agriculture. Maximum economic yield (MEY) management will help to alleviate poverty and improve the plight of resource-poor, marginal farmers by increasing productivity per unit of land. The whole range of production practices, from appropriate plant population to balanced fertilization, is integrated into MEY systems to attain highest net profits.

Agricultural production has not kept pace with population growth in Bangladesh. A major objective of this study was to identify those production practices which will increase unit crop yields, reduce unit costs and, thus, generate sufficient income to allow farmers to continue to farm. These steps are essential to enable food production sufficient for a growing population.

New technology must also arrest soil degradation and help to assure a cleaner environment. The purpose of this research was to determine the maximum attainable yield of Boro rice under appropriate management.

During 1994 Boro season, two field experiments were conducted at BINA Farm, Mymensingh, and in a farmer field at Magura. There were five treatments, replicated four times in randomized block design, with plot size of 4m x 5m. Fertilizer recommendations for targeted yields were based on the site-specific soil tests. Rates of all fertilizer nutrients except nitrogen (N) were applied at transplanting. Nitrogen as urea was applied in three equal splits at land preparation, maximum tillering and at panicle initiation stages. The rice cultivar BR-14 was planted at a spacing of 15 cm x 25 cm.

Results

Rice yields are presented in **Tables 1 and 2**. Grain and straw yields of Boro rice for both locations were significantly affected by different fertilizer treatments. At the BINA Farm, the highest grain yield

Table 1. Combined effect of mineral and organic fertilization on the grain and straw yield of rice (Boro, var. BR14) grown at BINA Farm, Mymensingh, during 1994.

No.	Fertilizer treatment, kg/ha: N	P	K	S	Zn	Grain yield, t/ha	Straw yield, t/ha	% increase over control: Grain yield	Straw yield
T_1	0	0	0	0	0	2.62	2.87	—	—
T_2	200	65	166	40	5	7.15	7.73	173	169
T_3	½ of T_2+5 t/ha cowdung					5.92	6.55	126	128
T_4	T_2+5 t/ha cowdung					6.91	8.35	164	191
T_5*	140	43	83	30	4	6.45	6.63	146	131

*Fertilizer recommendation for high yield goal, from current Fertiliser Guide.

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Table 2. Combined effect of mineral and organic fertilization on the grain and straw yield of rice (Boro, var. BR14) grown at Magura farmer's field during 1994.

Fertilizer treatment, kg/ha						Grain yield, t/ha	Straw yield, t/ha	% increase over control	
No.	N	P	K	S	Zn			Grain yield	Straw yield
T_1	0	0	0	0	0	3.30	3.87	—	—
T_2	180	65	145	30	4	7.37	7.98	123	106
T_3	½ of T_2+5 t/ha cowdung					5.69	6.58	72	70
T_4	T_2+5 t/ha cowdung					7.11	8.50	115	120
T_5*	140	43	83	30	4	6.32	7.13	92	84

*Fertilizer recommendation for high yield goal, from current Fertiliser Guide.

of 7.15 t/ha was recorded with the T_2 treatment (nutrients for targeted yields of 7.5 t/ha based on soil analysis). The highest grain yield of 7.37 t/ha in the farmer plot at Magura was also obtained with treatment T_2. Lowest grain yields of 2.62 t/ha at BINA Farm and 3.30 t/ha in the farmer plot were recorded in control plots where no fertilizer was added. On the other hand, T_4 gave the highest straw yield of 8.35 t/ha at Mymensingh and 8.50 t/ha at Magura. Application of cowdung along with the fertilizer did not produce any additional yield benefit at either location, other than an increase in straw yield at Magura.

Partial budget analysis and marginal analysis on the total products from the two field experiments were also done. Maximum net benefit of Tk.39,438.00 (US$985.00) was obtained on the BINA Farm with treatment T_2, followed by Tk.37,315.00 (US$932.00) for treatment T_5. Marginal analysis of fertilizer response data gave the highest marginal rate of return (MRR) of 1,275 percent with treatment T_5 followed by 338 percent in T_3 and 74 percent in T_2. At Magura, maximum net benefit of Tk.41,756.00 (US$1,044.00) was obtained from treatment T_2, followed by Tk.39,763.00 (US$994.00) with treatment T_4. The highest MRR (631 percent) was recorded with treatment T_5, followed by 230 percent with treatment T_3. For Magura, treatment T_5 . . . with the highest MRR of 631 percent and third highest net benefit of Tk.37,087.00 (US$927.00) . . . would be the most economically viable treatment. At the BINA farm, treatment T_5 was found to be most economically viable, with a 1,275 percent MRR and net benefit of Tk.37,315.00 (US$932.00)

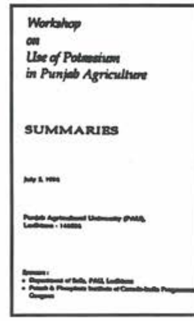
Conclusion

Bangladesh needs to produce 50 million tonnes of paddy rice by 2025, compared to the present level of 25 million tonnes, to feed a population of 200 million. The potential to achieve this level of production is indicated by the yield level of 7 t/ha recorded in our experiments. This will help release some lands currently under rice and divert them to oilseeds and pulses which are major import items of Bangladesh. ■

Note: International articles which appear in *Better Crops with Plant Food* use metric units of measure, such as kilograms and hectares. In general, articles from the U.S. and Canada appearing in this publication use U.S. (formerly called English) units, such as pounds and acres. The units can be converted from one system to the other using multiplication factors provided in the publication. See page 23.

India

Workshop on Use of Potassium in Punjab Agriculture


Workshop
on
Use of Potassium
in Punjab Agriculture

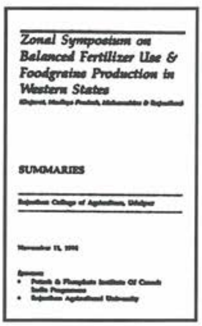
SUMMARIES

Ludhiana

A one-day workshop on potassium (K) use in Punjab agriculture was sponsored by the Potash & Phosphate Institute of Canada (PPIC)-India Programme, in conjunction with Punjab Agricultural University, on July 5, 1994.

Thirteen papers were presented focusing on K use pattern and projections, available K and soil test crop response.

Those in attendance were addressed by Mr. R.N. Gupta, Financial Commissioner; Dr. D.R. Bhumbla, Former Agriculture Commissioner, Govt. of India; Dr. S.S. Bains, Director of Agriculture, Punjab; Dr. K.S. Aulkah, Director of Research; Dr. Bhajan Singh, Head, Department of Soils, Punjab Agricultural University; and Dr. G. Dev, PPIC-India Programme.


Zonal Symposium on
Balanced Fertilizer Use &
Foodgrains Production in
Western States

SUMMARIES

Zonal Symposium on Balanced Fertilizer Use & Foodgrains Production in Western States

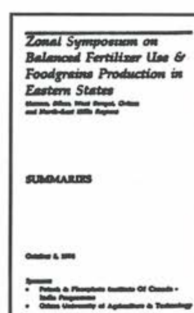
Udaipur

In conjunction with Rajasthan Agricultural University, the PPIC-India Programme, Gurgaon, organized a symposium on balanced fertilizer on November 11, 1994.

Papers presented encompassed balanced fertilization with NPK for increased production of cereals, pulses, and foodgrains and the role of soil testing in ensuring balanced fertilizer usage.

Dr. R.K. Patel, Vice-Chancellor, Rajasthan Agricultural University; Dr. S.B. Kadrekar, Former Vice-Chancellor Konkan Krishi Vidyapeeth, Dapoli, Maharashtra; Dr. G.L. Jain, Dean Post Graduate Studies, RAU; Dr. L.L. Dhakar, Professor and Head, RAU; and Dr. G. Dev, Director, PPIC-India Programme, addressed the attendees.

Zonal Symposium on Balanced Fertilizer Use & Foodgrains Production in Eastern States


Zonal Symposium on
Balanced Fertilizer Use &
Foodgrains Production in
Eastern States

SUMMARIES

Bhubaneswar

Experts representing state agricultural universities, state department of agriculture and the fertilizer industry participated in the "Balanced Fertilizer Use & Foodgrains Production in Eastern States" symposium sponsored by PPIC-India Programme in collaboration with Orissa University of Agriculture and Technology on October 5, 1994.

Eight papers were presented with topics on balanced fertilization with NPK for increasing wheat, rice, pulse and corn production.

Dr. I.C. Mahapatra, Former Vice-Chancellor of Orissa University of Agriculture and Technology, opened the program emphasizing the usefulness of balanced fertilization to obtain increased production. The keynote speaker, Dr. N. Panda, Former Chancellor, Sambalpur University, discussed the importance of soil testing and Dr. G. Dev, Director, PPIC-India Programme, stressed the need for the symposium.

Summaries of presentations for the workshops and symposium are available by contacting Dr. G. Dev, Director, PPIC-India Programme, Sector 19, Dundahera, Delhi-Gurgaon Road, Gurgaon-122016, Haryana, India.

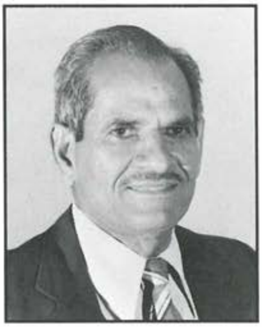
Dr. Anand Swarup Receives 1994 PPIC-India Programme Award

Dr. Anand Swarup

THE 1994 PPIC Award on Management and Balanced Use of Inputs in Achieving Maximum Yield went to Dr. Anand Swarup, Senior Scientist, Central Soil Salinity Research Institute, Karnal. Dr. Swarup obtained his Ph.D in Soil Science from the Indian Agricultural Research Institute, New Delhi, in 1976. He has 18 years of research experience and over 100 publications. His findings revealed that proper management of salt-affected soils through appropriate amendments and balanced use of fertilizer nutrients and irrigation are extremely important for improving and maintaining fertility and sustaining crop productivity at maximum level.

Dr. Swarup is recipient of the FAI Silver Jubilee Award of Excellence in 1990 and award for the best article published in *Fertiliser News* in 1988-89. ■

Dr. G. Dev Elected President, Indian Society of Soil Science



Dr. G. Dev

DR. G. DEV, Director of the PPI/PPIC India Programme, was recently elected President of the Indian Society of Soil Science. The Society has a membership of more than 2,000 scientists. Dr. Dev will serve as President of the group for 1995 and 1996.

Since 1989, Dr. Dev has directed the agronomic research and education program of PPI/PPIC in India. His home and office are located at Dundahera, Gurgaon, in the province of Haryana, near New Delhi.

Dr. Dev received his undergraduate training at the University of Delhi and earned his doctorate in Soil Science at the Indian Agricultural Research Institute in New Delhi. He has traveled to Norway, Canada, the U.S. and other countries for consultation, study and teaching. He has guided 23 M.Sc. and seven Ph.D. students.

During his distinguished career, Dr. Dev has held positions of increasing seniority in agricultural research and education in India. He has published numerous research papers as well as reviews and popular articles. A member of five scientific societies, Dr. Dev's work has resulted in many awards and recognitions including the 12th International Soil Science Congress Commemoration Award of the Indian Society of Soil Science. He is also a Fellow of the Indian Society of Soil Science. ■

The Invisible Three Percent

POLITICIANS know that only three percent of the U.S. population is farming. Concern for farmers is often overshadowed by the more visible issues of crime, civil rights and abortion. However, the invisible three percent in agriculture provides the United States with an unparalleled standard of living.

Many people don't know what farming is today, or the role of the U.S. Department of Agriculture (USDA). A recent book asked the question, "What was the fastest growing agency in the federal budget during the 1980s?" The Pentagon? No, it was the USDA. This leads the uninformed to the assumption that the farmer is feeding at the public trough and is a big contributor to the deficit.

I asked 10 reputable economists, "If you were in Congress, would you vote for farm subsidies or not?" Not one gave a direct answer. One said, "Farm programs take income from the middle class and give it to wealthy farmers."

I asked 20 college professors, "What government agency handles food stamps?" Only three out of 20 knew food stamps to be the largest part of USDA's budget—and one of its most controversial.

Evidentally, we have done a poor job of educating the public about modern farm complexities, farm economics, the risk involved, the environmental importance and the world picture. The tremendous role of agriculture in today's world demands more education at all levels. The agricultural society must develop an awareness to the issues of global farming and food production, not just for the future farmer, but for the future consumer as well.

We could begin by providing the tools of learning at an early age. Educational materials such as PPI's *Fun with the Plant Nutrient Team* would be a positive step in making the invisible finally visible.

J. Fielding Reed

BETTER CROPS
WITH PLANT FOOD

Potash & Phosphate Institute
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