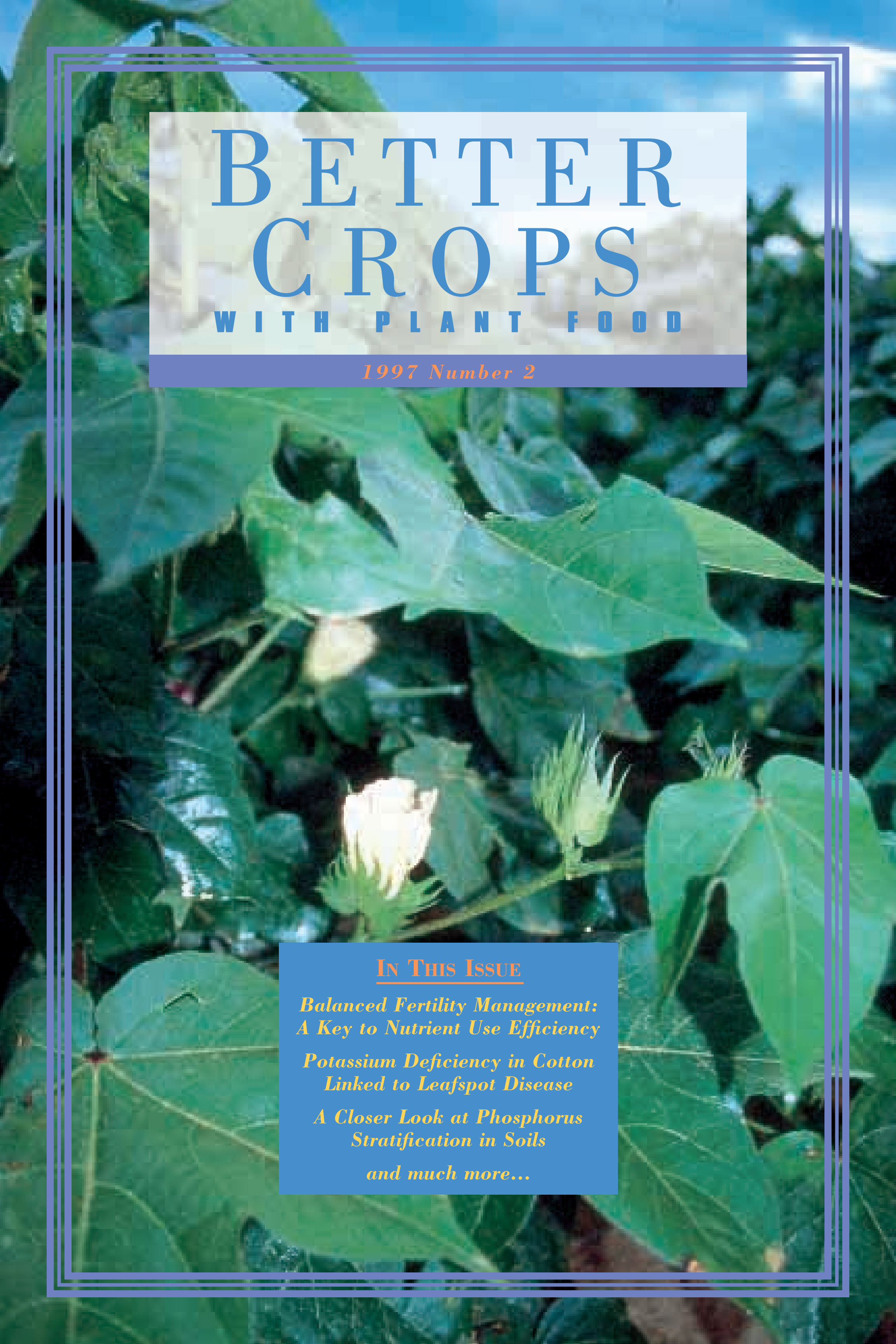

BETTER CROPS
WITH PLANT FOOD

1997 Number 2

IN THIS ISSUE

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Our Cover: Cotton plants in bloom.
Cover Photo: Harlen Persinger

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CONTENTS

Balanced Fertility Management: A Key to Nutrient Use Efficiency

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

A balanced fertility program is essential for optimizing yields, increasing profits, and improving the efficiency of fertilizer applications. For non-legumes, nitrogen (N) may be the most common limiting nutrient. However, without balanced nutrition, fertilizer N applications may be less efficient, and part of the fertilizer investment is wasted. To address these issues, a four-year study was conducted on a Crosby silt loam soil near Springfield, Ohio. The study examined four preplant N rates: 0, 80, 160, and 240 lb/A. In addition, several soil potassium (K) levels were included to test how K and N interacted to influence corn grain yield, N uptake efficiency, and soil N levels after harvest.

Balanced fertilization practices produce higher yields, greater profitability, and improved environmental protection: goals which every top producer should strive to achieve.

The effects of K and N on corn grain yield are presented in **Figure 1**. In considering only the effects of N, corn grain yields were highest at rates of at least 160 lb/A. However, the yields attainable at this level of fertilizer N increased as the K level of the soil became greater. The highest yields occurred when the soil K levels were at least 232 lb/A. These results demonstrate that higher levels of soil K are necessary to ensure that crop yields reach their fullest potential.

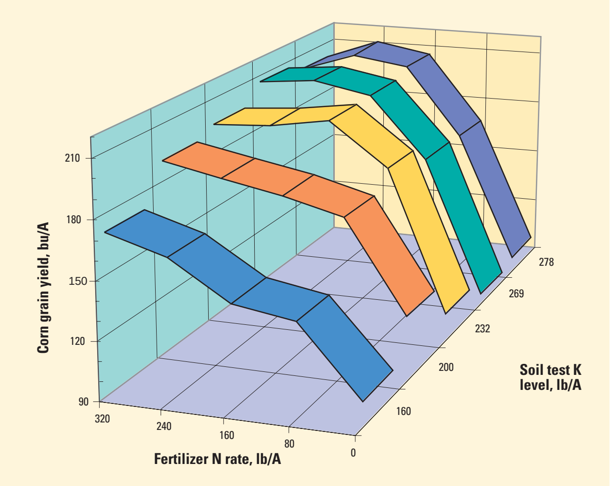

Figure 1. Corn grain yield response to fertilizer N rates and soil test K levels on a Crosby silt loam soil near Springfield, OH.

Nitrogen and K also complement each other to optimize the efficiency of N fertilizer applications. The percentage of the fertilizer N used by each acre of corn was calculated for each level of applied N as well as each soil K level. These data are plotted in **Figure 2**. The most noticeable result is that the percentage of applied N fertilizer used by the corn crop decreased with greater N

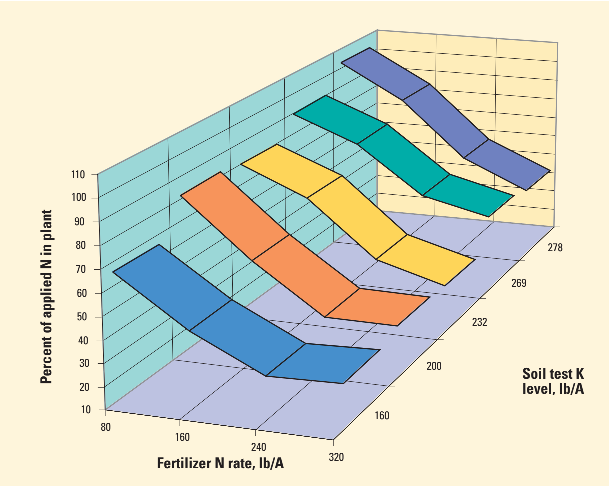

Figure 2. The effect of fertilizer N rates and soil test K levels on the N uptake efficiency of a corn crop grown on a Crosby silt loam soil near Springfield, OH.

Higher levels of soil K resulted in greater use of applied N fertilizer by the corn crop. Other data from this experiment (not presented here) showed that K did not increase fodder N uptake significantly, but it did produce significant increases in N uptake by the grain. The removal of N by the grain was therefore most likely responsible for the observed increases in whole plant uptake of N with increased K levels in the soil.

rates. This occurred because the amount of N taken up by the crop initially increased as increasing amounts of fertilizer were applied; however, as N rates continued to increase, crop uptake began to reach a plateau. When N uptake reached this maximum, lower percentages of fertilizer N were utilized.

The effects of K are also evident.

So far, increased soil K levels have been shown to improve the efficiency of fertilizer N utilization and to increase the yields attainable at higher N rates. Both of these effects may work together to reduce the quantity of N fertilizer remaining in the soil after harvest. **Figure 3** shows the percentage of applied N fertilizer remaining in the top 3 ft. of soil after grain harvest for five different soil test K levels. Higher soil K levels resulted in a smaller percentage of the applied N fertilizer remaining in the soil. These lower levels may have resulted from the greater fertilizer N removal by corn growing on the areas with higher K levels.

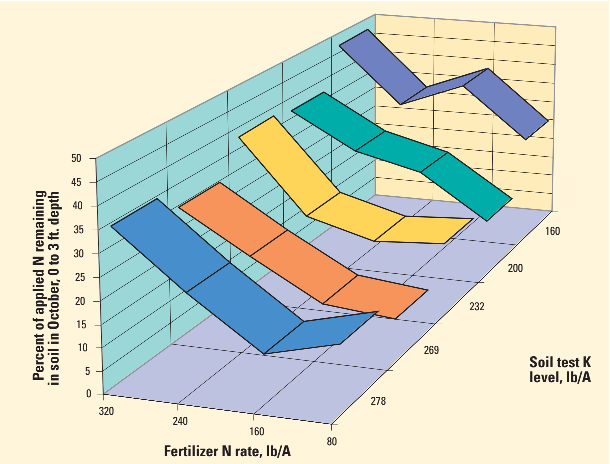

Figure 3. The effects of N rates and soil test K levels on the percent of applied fertilizer N remaining in the upper 3 ft. of a Crosby silt loam soil in October after corn grain harvest.

The data from this study also show that N and K work together to maximize profitability. The change in yield response to increasing fertilizer N applications was calculated for each soil K level. Income generated or lost from each fertilizer increment was based upon a price of $2.90/bu for corn and $0.25/lb of N for fertilizer.

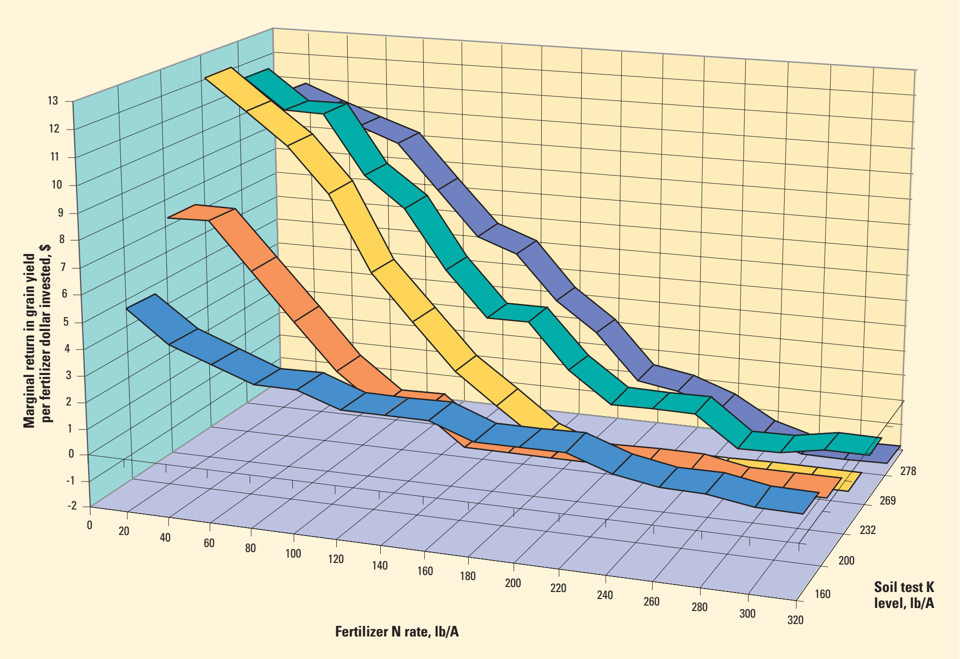

Figure 4. Marginal returns to N fertilizer investment for incremental changes in N rate at different soil test K levels (corn grain price set at \$2.90/bu and fertilizer N fixed at 25¢/lb).

The income from yield was compared to the investment in fertilizer N.

The results of this analysis are plotted in **Figure 4**. The most evident feature of this graph is the well-known relationship that marginal return is highest at the initial increments of fertilizer N, but begins to reach a plateau at higher fertilizer N levels. The data clearly show that higher levels of soil K greatly increase the marginal returns from applications. This response is directly related to the heightened yield response at the higher soil K levels. Eventually, N additions either produce no additional profit or begin to reduce profit. Higher soil test K levels allow corn to achieve its maximum profitability at lower N rates.

The results from this study have several implications for N and K management. When N and K work together, yields and N uptake are superior to those arising from N alone. Higher K levels also reduce the amount of fertilizer N needed to maximize profitability. The increased yields and N levels in the crop lead to a more efficient use of applied N fertilizer. When more of the N fertilizer is used by the crop, less is left over in the soil after harvest. Reduced soil N levels mean reduced chances for groundwater contamination through runoff or leaching. BC

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TEXAS

A Closer Look at Phosphorus Stratification in Soils

By C.G. Coffman

In an effort to address concerns about phosphorus (P) fertilizer recommendations, soil samples were collected at various depth increments from seven fields across much of Texas. The samples were then analyzed for P, using different extractant procedures. This article presents and discusses the results of these analyses relative to the stratification of P in Texas soils.

Average corn grain yields have increased markedly in the U.S. since the mid-1930s. The development of hybrid corn in the late 1930s gave rise to a significant increase in corn grain yields. Another major contributing factor to the yield increases experienced after the early 1950s was the rapid adoption and increased use of commercial fertilizer on corn fields. Phosphorus fertilizer had a significant role in the yield increases experienced by corn producers.

Soil testing laboratories at the land grant universities across the U.S. aided in the assessment of the need for P fertilization of corn fields. Some fields were inherently low in available P, while others were adequately supplied with this essential plant nutrient. When P was needed on Texas corn fields, applications generally were made by broadcasting the fertilizer on the soil surface prior to primary tillage operations. During the past decade or two, there has been an increasing number of crop producers applying P fertilizer in-furrow at planting or near the seed.

Seedbed preparation in most corn fields across Texas, until the early 1980s, included relatively deep (8 to 12 inches) primary tillage operations. However, during the last fifteen years, conservation of crop residue on the soil surface and reduced tillage have been adopted extensively by corn producers. During this period of time, an increasing number of complaints have been received by the Soil Testing Laboratory at Texas A&M University concerning the perceived lack

TABLE 1. Phosphorus concentrations of soil samples collected from seven farms analyzed using the "Acidified Ammonium Acetate" procedure at Texas A&M University.

Soil depth, inches	Phosphorus concentrations of soil samples, ppm						
	Donaldson Farm	Luling Farm	Baker Farm	Fleming Farm	Ejems Farm	Price Farm	Patman Farm
0-3	170	73	66	85	41	121	129
3-6	168	68	53	59	16	37	67
6-9	102	42	29	26	12	14	39
9-12	67	24	28	22	10	14	33
12-18	67	16	28	22	12	15	25
18-24	70	14	27	22	13	18	20

TABLE 2. Phosphorus concentrations of soil samples collected from seven farms analyzed using the "Weak Bray" procedure at Kansas State University.

Soil depth, inches	Phosphorus concentrations of soil samples, ppm						
	Donaldson Farm	Luling Farm	Baker Farm	Fleming Farm	Ejems Farm	Price Farm	Patman Farm
0-3	10	13	10	13	35	35	24
3-6	7	10	6	8	13	11	7
6-9	5	5	2	1	4	4	2
9-12	2	2	2	1	4	3	2
12-18	3	1	2	1	4	2	1
18-24	3	0	0	0	3	2	1

of correlation between the rate of P fertilizer recommended for corn fields and the grain yield responses obtained from the addition of P. Crop producers and others have been concerned that P fertilizer recommendations made by the soil testing laboratories are too conservative. Many producers believe that they have observed a crop response to annual applications of P, even when their soil test reports have recommended that none (or very low rates) be added.

Phosphorus Levels by Depth

Soil cores were collected from the top 2 ft. of the profile at multiple locations across each of seven fields. Each core was sub-divided into six portions as follows: 0 to 3 in., 3 to 6 in., 6 to 9 in., 9 to 12 in., 12 to 18 in., and 18 to 24 in. The composite of the respective depth segments from each field were ground and dried, then analyzed using the following three extractants: Acidified Ammonium Acetate run by Texas A&M University; Weak Bray run by Kansas State University; and Mehlich 3 run by Oklahoma State University.

The P concentrations in the surface samples are significantly higher than those present in the lower soil segments (**Tables 1-3**). At all locations, the soil P concentrations decreased markedly below the top 3 to 6 in. segment. In some cases, the decrease occurred below the 0 to 3 in. segment. Using the values from the acidified ammonium acetate procedure (**Table 1**), the comparative P concentration in the top two segments (i.e., the 0 to 3 in. and the 3 to 6 in.) decreased by 61, 69, and 48 percent for the fields on the Ejems, Price, and Patman farms, respectively. The P concentration decreased from the 3 to 6 in. segment to the 6 to 9 in. segment by 39, 38, 45, and 56 percent for the fields from the Donaldson, Luling, Baker, and Fleming farms, respectively.

The test value of 44 parts per million (ppm) P was considered the "critical" level, above which P fertilizer was not recommended. Thus, using the average of the top two 3 in. soil segments, no P fertilizer

TABLE 3. Phosphorus concentrations of soil samples collected from seven farms analyzed using the "Mehlich 3" procedure at Oklahoma State University.

Soil depth, inches	Phosphorus concentrations of soil samples, ppm						
	Donaldson Farm	Luling Farm	Baker Farm	Fleming Farm	Ejems Farm	Price Farm	Patman Farm
0-3	27	11	9	10	31	26	33
3-6	25	8	5	6	14	7	10
6-9	13	5	2	2	4	2	3
9-12	8	3	2	2	3	2	3
12-18	7	2	1	2	3	1	2
18-24	6	2	1	1	2	1	2

was recommended for six of the seven fields. However, the soil test P values from the 6 to 12 in. segments ranged from very low to medium, and suggest a grain yield response from P fertilizer applications.

Since P is relatively immobile in the soil, and with sampling of the soil being predominately from the top 6 in. of the profile for fertilizer recommendations, several questions arise: 1) "Should one rely on the 0 to 6 in. segment of the soil profile for fertilizer recommendations?" (Or, should the top 2 or 3 in. of each soil core be removed before compositing the samples for analysis?) 2) "Should P fertilizer be injected into the soil?" 3) "Will continued use of conservation tillage practices intensify the stratification of P in the surface soil layers?" 4) "How do extremely "dry" or "wet" growing conditions affect the absorption of P by crop roots, and the crop's yield response to additional P applications?" and 5) "How will the recommendations of other plant nutrients be affected if a different soil segment is used than the traditional 0 to 6 in. soil core?"

Certainly, the awareness of the P stratification in Texas soils has necessitated additional field studies to answer some of these questions.

Dr. Coffman is Extension Agronomist, Texas Agricultural Extension Service, College Station, TX.

Research Notes

Alberta: Canola Root Rot and Yield Response to Liming and Tillage

In this research, the effects of aglime were studied on conventional tillage and no-till systems. The aglime increased soil pH and nitrate-nitrogen (NO_3-N) in the top 8 inches of soil, but did not alter pH below 8 inches and had no effect on extractable phosphorus (P), exchangeable aluminum (Al), soil water, and ammonium-N (NH_4-N). Liming did suppress weed growth and reduced the severity of brown girdling root rot (BGRR). It also increased grain yield and dry matter production of canola.

Liming was effective in each tillage system, but was more effective with no-till. Tillage reduced both soil water and growth of canola. Reduced soil water...and increased weed populations...appeared to be responsible for reduced crop growth in the conventional tillage system.

Source: Arshad, M.A., K.S. Gill, T.K. Turkington, and D.L. Woods. 1997. Agron. J. 89:17-22.

Information Agriculture Conference

PLANNED FOR AUGUST 6 - 8, 1997

The third Information Agriculture Conference (InfoAg '97) will be returning to the Krannert Center for the Performing Arts, University of Illinois, Urbana. The conference will begin on Wednesday, August 6 and continue through Friday, August 8, 1997.

Organizers are PPI and the Foundation for Agronomic Research (FAR). Sponsors of InfoAg '97 are: Ag-Chem Equipment Co., Inc.; Case Corporation; CCNet Agribusiness Task Force; Environmental Systems Research Institute (ESRI); *Farm Chemicals* Magazine; Gateway 2000; John Deere Precision Farming; National Center for Supercomputing Applications; Natural Resources Conservation Service (USDA-NRCS); *PrecisionAg Illustrated* Magazine; The Fertilizer Institute; and the University of Illinois College of Agricultural, Consumer and Environmental Sciences.

The 1997 program is structured for introductory, intermediate and advanced tracks to accommodate different interests and levels of experience. These tracks will be directed to the dealer, farmer, integrated crop management and advanced agronomic audiences. Concurrent sessions will offer the opportunity for interaction with specialists in data management, geographic information systems (GIS) software, yield mapping, variable-rate technology and global positioning system (GPS).

The popular "CyberFarm" and "CyberFarm Diner" will be a returning attraction to InfoAg '97. This program will feature how farmers and agri-businesses and public agencies are working together via an Internet link to share ideas, transfer data and conduct business. There will also be a "CyberDealership" workshop, a session on advanced diagnostic tools, and a feature for those getting started in precision management.

Exhibitors will display the latest in technology, products and services, with introductions of some new developments expected.

Registration fees are $250 per delegate before July 7 and $350 after July 7, 1997. Student registration fees are $100.

For registration information contact:

InfoAg Registration Department
Linda McAbee
The Fertilizer Institute
501 Second Street, NE
Washington, DC 20002
Phone: 202-675-8250
Fax: 202-544-8123

For exhibitor information, contact:

Bill Agerton, PPI
655 Engineering Drive, Suite 110
Norcross, GA 30092-2837
Phone: 770-825-8074
Fax: 770-448-0439
E-mail: bagerton@ppi-far.com

Additional details will be available on the Information Agriculture Conference web site at:
http://w3.aces.uiuc.edu/INFOAG/
or the PPI Home Page at:
http://www.agriculture.com/contents/ppi/

Potassium Deficiency in Cotton Linked to Leafspot Disease

By Glen Harris

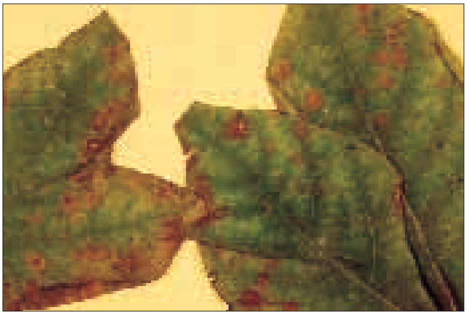
Late-season K deficiency and associated leafspot are not new to Georgia cotton. However, over the past few years, this problem has occurred more frequently, more severely and much earlier in the growing season. In some worst cases, cotton was totally defoliated soon after the fourth week of bloom.

Cotton is sensitive to potassium (K) deficiency. Almost every case of leafspot investigated in recent Georgia studies involved low soil K, low petiole K, and/or low plant tissue K.

The first indication of this problem was actually the discovery of a new leafspot for Georgia – *Stemphylium*. It is estimated that 2,000 acres of Georgia cotton were infected with this new disease in 1995 and up to 20,000 acres in 1996. The symptoms of leafspot are small brown lesions caused by the fungal organisms *Cercospora* and *Alternaria* in addition to *Stemphylium*. Upon further investigation, it was discovered that the leafspot was actually secondary to the primary problem – K deficiency. It is well known that K adds strength to plant leaf cells and the lack of K in leaf cells makes them weak and susceptible to secondary fungal infection.

Leaf cells of K-deficient cotton are weak and susceptible to secondary fungal infections. Nearly every case of leafspot disease reported in Georgia during the past two years was found to be due to low plant K. Disease symptoms are shown here on K-deficient cotton leaves.

In almost every case where leafspot was investigated, low soil K, low plant tissue K and/or low petiole K was discovered. Low petiole K appeared to be the best indicator. In some cases the problem was traced back to inadequate K fertilization. Some cases were under dryland conditions where low soil moisture was suspected of reducing uptake of K. Some cases occurred on short-season varieties where intense demand for K in a short period of time was suspected as the main problem. A few cases occurred with high soil magnesium (Mg) levels which were thought to have caused competition for K uptake and subsequent K deficiency. The majority of cases, however, were discovered on full season varieties under irrigation around the fourth week of bloom with heavy fruit set. This timing and situation correspond with a heavy demand for K. The roots of the cotton plant also start to decline at this



These cotton leaves show symptoms of *Stemphylium* leafspot and K deficiency.

time due to competition for carbohydrates by developing bolls. This adds to the challenge of taking up soil K at this time. Even with irrigation, adequate water may not have been provided during a critical dry period, or with adequate water, may have contributed to higher yield conditions and K demand.

Once K deficiency sets in and leafspot appears, fungicide sprays do not alleviate the condition since the primary problem is K deficiency. If K deficiency is detected around the fourth week of bloom and is not severe, foliar K sprays may lessen yield effects. Petiole testing could also help avoid this problem, since it is designed to predict nutrient deficiencies up to two weeks in advance, especially as the crop moves toward peak bloom. Unfortunately, if severe K deficiency occurs late (sixth week of bloom) foliar K sprays will likely not correct the problem. Also, K deficiency and leafspot are fairly common once cotton "cuts-out". No corrective treatment is recommended at this time.

Best Management Practices to Avoid Potassium Deficiency

- **Soil Testing** – The first and best line of defense for avoiding K-deficient cotton is soil testing. Maintaining soil test K levels in the medium to high range for cotton is recommended. Also keeping a good balance of other nutrients such as calcium (Ca) and Mg will help.
- **Split K Applications** – Since K is relatively mobile in sandy soils, split applications are recommended on soils with no clay subsoil in the top 16 inches. Apply half the K at planting and the remainder at side-dressing, sometime around the first square. This helps supply K at a time when demand increases rapidly and may even be helpful on "stiffer" soils.
- **Foliar Fertilization and Petiole Testing** – In most cases where soil K levels are maintained at medium to high levels, preplant soil applications of K fertilizer should provide enough K so that foliar applications will not be necessary. There are a number of cases, however, where a yield response to foliar applications may occur: deep sands, low-soil K at planting, high yield irrigated conditions, and during periods of limited soil moisture. The best way to determine the need for foliar K is by petiole testing. A complete petiole testing program is designed to predict nutrient deficiencies up to two weeks in advance, before any yield reductions due to deficiencies occur.

Excessive fertilizer rates should not be used as a strategy to avoid K deficiency. Other problems can result from nutrient imbalance. Getting back to the basics of soil testing, proper fertilization, and petiole testing should help eliminate K deficiency as a cause of yield reduction for cotton in the future. BC

Dr. Harris is Extension Agronomist, Department of Crop and Soil Science, University of Georgia, Tifton, GA 31794.

VIRGINIA

Irrigation with Balanced Fertilization Increases Corn Yields

By N.L. Powell

Water is a serious limiting factor for consistently good corn yields in southeastern Virginia. Even though the annual rainfall may average 48 inches, the rain generally does not come at the best times during the growing season to maintain optimum plant growth and development.

Coarse textured surface soils and acid subsoils are prevalent in the region, causing shallow root systems which result in plant water stress during dry weather. Consequently, rain-fed corn production is quite erratic from year to year. During an 8-year study at the Virginia Tech Tidewater Agricultural Research and Extension Center, rain-fed corn yields ranged from 50 to 160 bu/A, with a 110 bu/A average (see **Table 1**). Total fertilizer applied annually to these plots was 150 lb/A nitrogen (N), 75 lb/A P_2O_5, and 150 lb/A K_2O.

For high, efficient and consistent corn yields in southeastern Virginia, irrigation is a proven practice and must be used in conjunction with sound fertility management practices including micronutrients.

During the first four years of this same period, using subsurface microirrigation tubing buried 15-inches below each row (3 ft. spacing), between alternate rows (6 ft. spacing), or below each third row (9 ft. spacing) corn yields averaged 159, 149 and 145 bu/A for the three spacings, respectively. The total annual fertilizer applied to these plots was 250-75-150 ($N-P_2O_5-K_2O$). While yields were considerably better than the rain-fed corn, they were lower than desired or anticipated.

The only management change made in the second four-year period was to apply 2 lb/A boron (B)

TABLE 1. Corn yields at Tidewater Agricultural Research and Extension Center.

Year	Subsurface irrigation 3 ft.	6 ft.	9 ft.	Not irrigated Grain yield, bu/A
	Grain yield, bu/A			
1986	151	149	144	123
1987	170	149	144	50
1988	161	153	156	112
1989	155	144	136	155
4-year average	**159**	**149**	**145**	**110**
1990	195	188	188	117
1991	190	208	160	131
1992	190	169	161	160
1993	194	166	148	50
4-year average	**192**	**183**	**164**	**114**
Difference between 4-year averages	**33**	**34**	**19**	**4**

Suffolk, Virgina

Subsurface microirrigated corn plots are shown here in Virginia research.

to the irrigated treatments through the subsurface system. Boron was applied in four applications of 0.50 lb/A at weekly intervals in late May and early June. All other fertilizer and management practices remained the same. Average yields over the four years increased by 33, 34, and 19 bu/A for the three irrigated spacing treatments. This suggests that B may have been an important limiting factor in the first 4-year period. Further research is needed to confirm this response.

Dr. Powell is Associate Professor, Crop and Soil Environmental Sciences, Virginia Tech Tidewater Agricultural Experiment Station, Suffolk, VA 23437.

Research Notes

Montana: Effect of Phosphorus Soil Test Level on Sorghum-Sudangrass Response to Phosphorus Fertilizer

Sordan 79 (sordan), an intraspecific sorghum-sudan hybrid, was the test crop in this greenhouse study. Three soils of different textures, cation exchange capacities, and calcium carbonate ($CaCO_3$) contents were used to test the response of sordan to phosphorus (P) applied to calcareous soils. Soil test P (bicarbonate-extractable) was adjusted to five initial levels, ranging from 2 to 60 parts per million (ppm). Fertilizer was applied at five rates, ranging from 0 to 80 lb/A.

Sordan response to P was linear at all soil test values below 30 ppm, but curvilinear above 30 ppm. However, soils with low soil test levels yielded less, even at the highest P rates, than those testing above 30 ppm and with no added P. Preplant and residual soil P levels increased with increasing P fertilizer rates. Researchers suggest that there are advantages associated with increasing bicarbonate-extractable P soil test values in those soils having excess $CaCO_3$ and pH values above 7.8. Maintenance applications of P appear to be necessary when P soil tests are 30 ppm or greater.

Note: A more detailed article on this subject will appear in a future issue.

Source: Bauder, J.W., S. Mahmood, B.E. Schaff, D.J. Sieler, J.S. Jacobsen, and E.O. Skogley. 1997. Agron. J. 89:9-16.

Low Phosphorus Soils Cause Major Problems with Forage and Livestock Production

By Tim Reinbott, Richard Mattas and Dale Blevins

The complex set of problems associated with grass tetany usually boils down to low magnesium (Mg) and calcium (Ca)...and perhaps phosphorus (P)...in the diet of cows, typically occurring in the late winter and early spring. The objective of the initial research was simply to learn how Mg and Ca contents of grass plants can be increased. Laboratory research using hydroponic plant culture, or water culture with pure chemicals, revealed that the P concentration around the roots was a major factor in controlling the uptake of Mg and Ca into grass plants. Work in the greenhouse showed that not only uptake of these two important macronutrients, but also their movement from roots to leaves was dependent on the P nutrition of the plant.

A project that was initially begun to address the sporadic problem with cattle, called grass tetany, has been expanded to increase the production of higher quality tall fescue.

The research was then moved to tall fescue pastures in Southwest Missouri where grass tetany is common. Soil tests indicated that soils in this area were naturally quite low in plant available P. The addition of 57 lb/A P_2O_5 resulted in significant increases in Mg and Ca contents of tall fescue leaf blades in late March and throughout April. These results are a testimony to the fact that a basic mechanism discovered in the laboratory with hydroponics can be reproduced in a field situation.

Although results from these experiments have been published, over 60 percent of all soil samples from Missouri analyzed by the University of Missouri Soil Testing Laboratory during the past couple of years remain low in plant available P. In an effort to get the attention of livestock producers and to get more producers to improve their soil P levels, we decided to determine the impact of adding P on forage production by tall fescue pastures on low P soils. We also studied the interaction of Mg and P fertilization on Mg content of tall fescue.

Missouri's soil P recommendation for cool season forage production in pastures is based upon grass legume mixtures. An optimal Bray-1 soil P level of at least 40 lb/A...20 parts per million (ppm)...is recommended. However, there is little information available on soil P levels required by tall fescue monocultures for optimal macronutrient quality and yield. On soils that ranged from 8 to 97 lb P/A, application of 57 lb/A P_2O_5 in early March increased early spring (late March/early April) tall fescue leaf content of Mg, Ca and P at each soil P level.

Magnesium fertilization (15 lb Mg/A) did not increase tall fescue leaf Mg content unless soil P levels were over 30 lb P/A (data not shown). However, treatments with both Mg and P fertilization increased leaf Mg concentration at all soil P levels (8 to 97 lb/A), as shown in **Figure 1**. These results

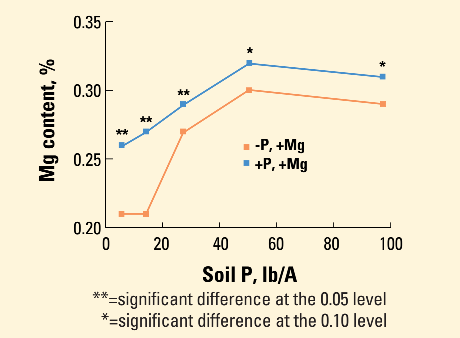


Figure 1. Leaf Mg content of tall fescue from plots treated with 15 lb Mg/A only and with 15 lb Mg plus 57 lb P_2O_5/A. Soil Bray-1 P levels ranged from 8 to 97 lb/A.

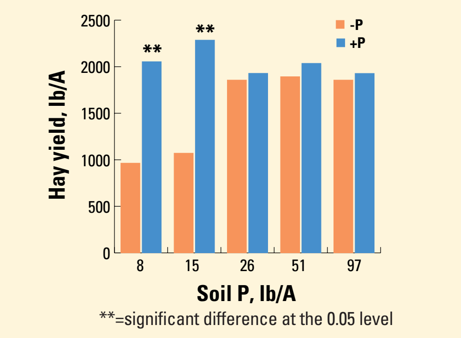


Figure 2. Hay yield of tall fescue harvested in May from plots either treated with or without 57 lb P_2O_5/A in early March. Soil Bray-1 P levels ranged from 8 to 97 lb/A.

are consistent with our previous results where Mg fertilization was effective only when P was also applied. These data may explain why in other studies Mg application of 100 lb/A on low P soils failed to increase leaf Mg content.

Phosphorus fertilization (57 lb P_2O_5/A) of soils with 8 or 15 lb Bray-1 P/A increased hay production by over 1,000 lb/A at both the May (**Figure 2**) and July harvests compared to untreated controls. Total hay production in spring and summer was increased by over one ton/A with P fertilization on these low P soils. Forage yields were not increased by P fertilization when soil P levels were at or above 26 lb/A. This confirms that the original 40 lb P/A soil test recommendation for mixed grass/legume pastures is on target for monoculture tall fescue forage production.

There was little increase in tall fescue forage production in October following P fertilization at any soil level. This indicates that most of the P applied in March had been taken up by the plants and/or fixed by the soil in a form not available to the tall fescue roots.

Annual P application (57 lb P_2O_5/A) was as effective as building soil levels to 26 lb P/A or greater for increasing both forage quality in the early spring and for increasing hay yield in May and July. Annual P fertilization may be a good alternative, economically, on certain soils that are very low in P since building up soil P levels to 40 lb/A would be more expensive.

Forage Mg, Ca and P contents of hay harvested in May were about one-half those found in grass samples in early April. In addition, P fertilization did not improve the Mg, Ca and P contents of the hay in May. However, forage from the July and October harvests was much higher in Mg, Ca and P contents than that harvested in May. Initially we were surprised by these findings but further investigation revealed that stems, which make up about one-half of the total hay yield in May, contain only about one-half the Mg, Ca and P found in leaves. The tall fescue harvested in July and October was nearly 100 percent leaves, and as a result, forage Mg, Ca and P contents were high. In order to produce high nutrient quality tall fescue hay, we are now working to minimize stem production. BC

Mr. Reinbott and Dr. Blevins are with University of Missouri, Columbia. Mr. Mattas is located at the University of Missouri Southwest Center, Mt. Vernon.

J. Fielding Reed PPI Fellowships Awarded to Six Graduate Students

Six outstanding graduate students have been announced as the 1997 winners of the J. Fielding Reed PPI Fellowship awarded 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 1997 recipients were chosen from nearly 40 applicants who sought the Fellowships. The six are: **Laurent Durand**, University of Manitoba, Winnipeg; **Rajiv Khosla**, Virginia Polytechnic Institute and State University (VPI & SU), Blacksburg; **Karl B. Ritchie**, University of Illinois, Urbana-Champaign; **James B. Sallee**, Michigan State University, Lansing; **Nathan A. Slaton**, University of Arkansas, Fayetteville; and **Qiupeng (David) Zeng**, University of California, Davis.

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

Scholastic record, leadership, and excellence in original research are among the important criteria evaluated for the Fellowships. Following is a brief summary of information for each of the 1997 Fellowship recipients.

Laurent D. J. Durand is a native of N.D. de Lourdes, Manitoba. He received his B.S.A. degree in 1995 at the University of Manitoba and is currently studying for his M.S. degree, also at the University of Manitoba, where he is President of the Soil Science Graduate Students Association. The primary objective of his thesis, 'Nitrogen Response Variability within Soil-Landscapes of Manitoba', is to develop a greater agronomic understanding of soil fertility variations within the landscape so that wise decisions can be made with respect to fertilizer inputs. Mr. Durand's career goal is to work in the extension area of agriculture or in retail sales as an agronomic consultant.

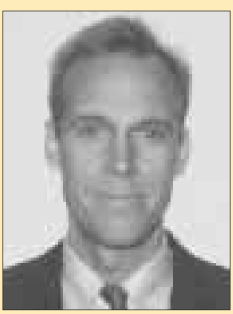
Rajiv Khosla was born in Allahabad, Uttar Pradesh, India. He earned his B.S. degree from the University of Allahabad in 1992. He is currently working toward his Ph.D. degree from VPI & SU, where he received his M.S. degree in 1995. He was the recipient of the P. Howard Massey Food and Nutrition Scholar Award at VPI & SU in 1996. His research project deals with the various aspects of developing nitrogen fertilizer recommendations for no-till dryland grain sorghum in Virginia. Mr. Khosla plans a career in research and extension, perhaps teaching at a university. He is also interested in working in the area of international research and development.

Karl B. Ritchie was born in Arco, Idaho. He received both his B.S. (1992) and M.S. (1994) degrees from Utah State University. He is presently studying for a Ph. D. at the University of Illinois. Among his many awards are

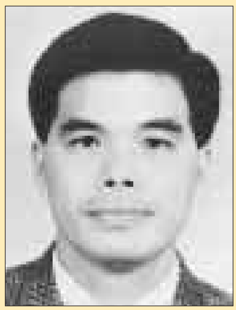
the Anheuser-Busch and the Union Pacific Railroad Scholarships. Much of his doctoral research has focused on nitrogen management and starter fertilizers in reduced-tillage corn. He is also utilizing weather and water sampling equipment to estimate evapotranspiration and nitrate leaching. Among his career objectives are conducting applied field research and helping to transfer technology between farmers and scientists.

James B. Sallee is from Wilmington, Ohio. He received his B.S. degree from Ohio State University in 1995. He is presently working on his M.S. at Michigan State University. Mr. Sallee was listed in 'Who's Who Among American College Students' while at Ohio State. His M.S. research deals with the degree to which soil series common to a three-state area (Michigan, Indiana, Ohio) differ in potassium (K) chemistry. Of particular interest is the determination of whether exchangeable or nonexchangeable soil K contributes most to plant growth. Mr. Sallee plans to seek employment with an agribusiness company or environmental consulting firm.

Nathan A. Slaton was born in Evansville, Indiana. He received his B.S. degree from Murray State University in 1986 and his M.S. degree in 1989 from the University of Arkansas. He has been active in student activities throughout his college career and served as President of the Agronomy Club while at Murray State. His dissertation research is focused on the evaluation of elemental sulfur as a soil amendment to improve rice growth and nutrient availability on alkaline soils in Arkansas. Following completion of his degree, Mr. Slaton plans to return to the Rice Research and Extension Center near Stuttgart to work as State Extension Rice Agronomist.



Qiupeng (David) Zeng is a native of China. He has a strong background in fertilizer promotion in China. In 1995 Mr. Zeng was the recipient of the Robert E. Wagner Award, sponsored by PPI. He is currently studying for his Ph.D. degree at the University of California, Davis. His research addresses soil availability, uptake and translocation mechanisms of K in pistachio to develop K diagnostic procedures and fertilizer recommendations. Mr. Zeng's career goal is to work in the area of market development in the potash and phosphate fertilizer industry, through research, extension and marketing.



The Fellowships are named in honor of Dr. J. Fielding Reed, retired president of the Institute, who now lives in Athens, Georgia. The Fellowship winners are selected by a committee of PPI scientists. Dr. A.E. Ludwick, PPI's Western U.S. Director, served as chairman of the selection committe for the 1997 Fellowships. BC

CANADIAN PRAIRIES

Fertilizer Management in Direct Seeding Systems

By T.L. Roberts and J.T. Harapiak

Direct seeding is the most common form of soil conservation used in the Canadian Prairies. In contrast to the restrictive conditions of no-till farming (such as no tillage prior to seeding and minimum tillage at seeding), direct seeders do not till in the spring before planting.

Direct seeding systems range from high disturbance systems that disrupt the entire soil surface to low disturbance systems with minimal soil disruption. Developments of air seeders and air drills have driven the successful adoption of this technology.

Although many farmers practicing direct seeding apply some of their fertilizer in the fall, there is increasing interest in applying all needed nutrients in a one-pass seeding and fertilizer operation in the spring. However, management of high rates of seed applied fertilizer, especially nitrogen (N), often discourage farmers from adopting a one-pass production system. This has prompted considerable research to determine how much fertilizer can be safely applied with the seed in small grains and oilseeds.

> Germination damage from seed-placed fertilizer will vary with season and climatic conditions as well as from field to field or within fields, depending on soil variability or properties. High rates of fertilizer can be safely placed with the seed if seedbed moisture is good. Increasing the separation between seed and fertilizer through higher seedbed utilization (SBU) or precision placement of fertilizer will further increase the margin of safety.

Fertilizer Management

Old recommendations suggested that seed row N should not exceed 40 lb/A as ammonium nitrate, or 25 lb/A as urea. And, seed row N plus K_2O should not exceed 40 lb/A. These recommendations were appropriate for seeding equipment, which placed seed and fertilizer in close contact, but are not applicable for today's seeders which cause some scatter between seed and fertilizer, or which can precisely place fertilizer away from the seed.

Many factors influence how much fertilizer can be safely applied with the seed. These include: row spacing, SBU, soil texture, moisture, organic matter, soil variability, fertilizer placement, seed furrow opener, source, and crop. The rate of fertilizer that can safely be applied in the seed row decreases as row spacing increases and SBU decreases. Seedbed utilization is a measure of the amount of soil used for applying fertilizer. It is calculated as follows:

$$\% \text{ SBU} = \frac{\text{width of seed row}}{\text{row spacing}} \times 100$$

Heavier textured soil tolerates more seed row N because the increased cation exchange and water holding capacity reduce ammonia toxicity.

TABLE 1. Approximate safe rates of urea N (lb N/A) that can be applied with the seed of cereal grains.

	1 inch spread Row spacing			2 inch spread Row spacing			3 inch spread Row spacing		
	6″	9″	12″	6″	9″	12″	6″	9″	12″
	% SBU			% SBU			% SBU		
Soil texture	**17**	**11**	**8**	**33**	**22**	**17**	**50**	**33**	**25**
Light (sandy loam)	20	15	15	30	25	20	40	30	25
Medium (loam to clay loam)	30	25	20	40	35	30	50	40	35
Heavy (clay to heavy clay)	35	30	30	50	40	35	60	50	40

Table 1 shows the Saskatchewan guidelines for urea that may be safely applied with the seed of cereals. Application rates for ammonium nitrate may be increased by about 25 percent. Ammonium nitrate is less damaging to the seed than urea. It has a higher salt index, but does not add to ammonia toxicity. These guidelines are approximations only. They assume seedbed soil moisture is good to excellent.

Higher rates of N may be tolerated if conditions are good (i.e., high cation exchange capacity and excellent seedbed moisture). North Dakota recommendations suggest maximum seed row N can range from 60 to 100 lb/A when using an air seeder (60 to 100 percent SBU) in a heavy textured soil.

Seedbed moisture is critical for safe application of fertilizer at the time of seeding. Small seeded crops like canola are especially sensitive, particularly when soil conditions are less than optimal and SBU is low (**Figure 1**). Spreading seed and fertilizer over more of the seedbed can partially compensate for low soil moisture with wheat and barley, but less so with canola.

High rates of seed row N not only reduce stand, but increase the risk of delayed maturity. Prairie research has consistently shown that when seed row N exceeds 30 lb/A and SBU is low, maturity of grain crops may be delayed 3 to 5 days, and under unfavorable harvest conditions, a 5 day delay could extend to two weeks. Cereals can tolerate a small amount of stand loss with little impact on maturity, however, once 15 percent of the stand is lost, the risk of delayed maturity becomes unacceptable.

Seed-placed urea is more damaging to cereals than ammonium nitrate, except at

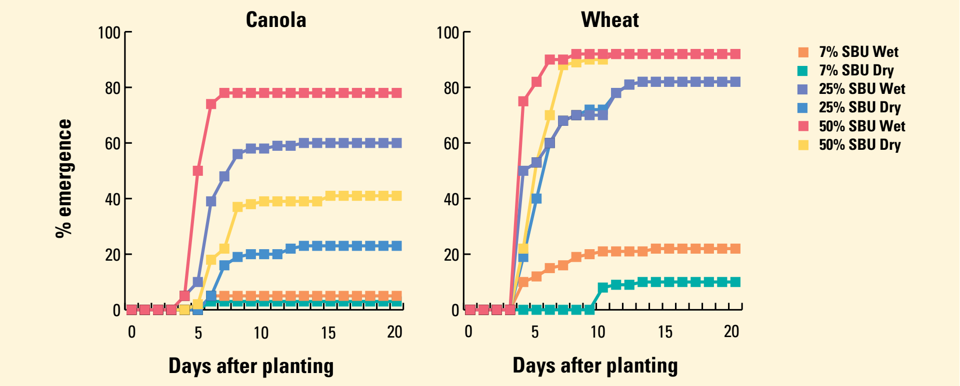


Figure 1. Seed-placed urea (60 lb N/A) reduces emergence under dry soil conditions and low SBU (Alberta data).

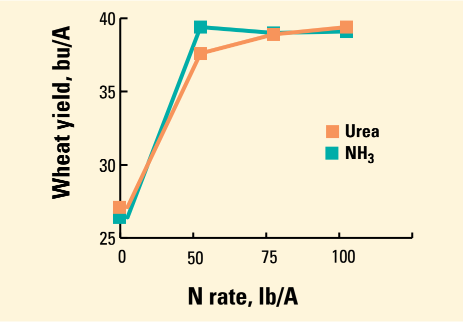


Figure 2. Wheat responds to side banded urea and NH_3 application in Alberta and Saskatchewan.

high SBU. Both are equally damaging to canola. Farmers are also interested in using anhydrous ammonia (NH_3) in direct seeding operations, but it was never considered feasible because of the high risk of germination damage from the ammonia. However, several Alberta and Saskatchewan trials show that NH_3 produces comparable results to urea, when it is precision placed (**Figure 2**). These trials were done with a commercial air seeder (Conserva-Pak™) with side band openers on 12 inch spacing. The fertilizer was placed 1 to 2 inches to the side and 1 to 2 inches below the seed. Caution should be used when precision placing fertilizers with side band openers, because opener wear can affect seed and fertilizer separation.

While most of the concern in one pass direct seeding is with N, farmers also seed place phosphorus (P), potassium (K) and sulfur (S). The effect of seed-placed P and K on wheat germination in the growth chamber is shown in **Figure 3A.** Both P and K reduced wheat emergence at rates above 40 lb/A, but only at rates greater than 80 lb/A were differences great. Canola did not tolerate any seed-placed fertilizer. Alberta field studies suggest small grains will tolerate 45 lb P_2O_5/A as monoammonium phosphate, 60 lb K_2O/A as potassium chloride and 30 lb S/A as ammonium sulfate, even when using a low SBU. Canola, however, is more sensitive than cereals, particularly to seed-placed ammonium sulfate.

Figure 3B illustrates the tolerance of wheat to seed-placed fertilizer blends containing N, P, K and S. Applying high rates of a 13-14-15-12 did not prevent germination, but did reduce and delay germination by several days. Wheat could tolerate up to 100 lb/A of the blend before emergence declined to less than 80 percent, but canola (data not shown), could only tolerate rates to 50 lb/A before serious germination problems occurred. BC

Dr. Roberts is Western Canada Director, PPI, Saskatoon, Saskatchewan. Mr. Harapiak is Manager of Agronomic Services, Western Cooperative Fertilizers Limited (Westco), Calgary, Alberta.

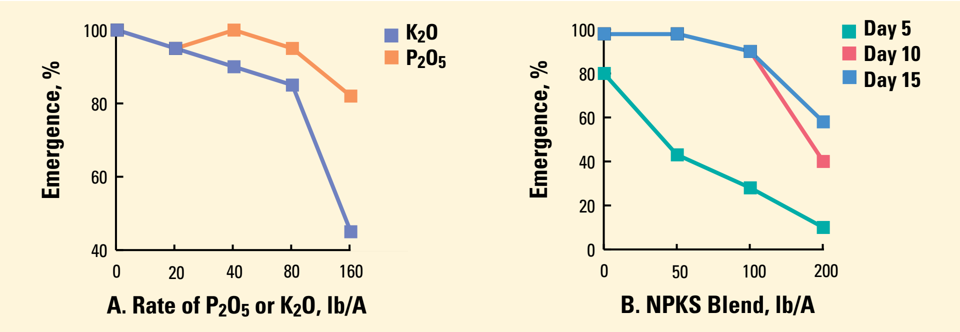


Figure 3. High rates of seed-placed (17% SBU) KCl and MAP and blended ammonium sulfate, MAP and KCl reduced and delayed wheat emergence in a clay loam Saskatchewan soil.

GEORGIA

Timing and Rates of Nitrogen, Phosphorus and Potassium for Top Yields of Quality Bermudagrass

By W.I. Segars and N.R. Usherwood

Excellent studies on bermudagrass nutrition have been conducted by leading scientists throughout the South. Field research findings provide the basic ingredients for bermudagrass production systems needed for this year and beyond.

> Nutrient management in a high yield, high quality production system enables bermudagrass producers to grow forage needed for livestock on fewer acres and at lower cost per ton. This article lists key facts based on research with bermudagrass in the South.

Balanced Nutrition is Essential for Optimum Bermudagrass Development

Nutrition is only one of the vital inputs for high yield, quality, stand longevity, and input use efficiency of bermudagrass. Other management practices ... such as soil preparation for stand establishment, soil acidity correction, variety selection, harvest frequency, crop protection management, timeliness of operations, or even the symbiotic relationships between inputs ... improve yield and quality. Nutrient management needed for top quality bermudagrass production then becomes one of balancing nutrients available from the soil and those from fertilizer and other sources.

The Goal ... A Quality, Dependable Low-cost Feed Source for Livestock

The goal in bermudagrass production is to produce a quality feed source with protein, total digestible nutrients (TDN), and other ingredients in tune with livestock requirements. Nutrient availability and balance have a lot to do with meeting such objectives. Nutrient management in a high yield, high quality production system allows growers to produce the tons of quality forage needed for their livestock on fewer acres and at a lower cost per ton.

Total Nutrient Requirements of Bermudagrass Change with Management Practices, Yield Level, and Forage Quality Expectations

Nutrient requirements of bermudagrass change with management. For example, more frequent harvests at an earlier plant growth stage will result in lower yields of dry matter but higher protein, TDN and digestiblity of the harvested forage. Georgia research with 2, 4 and 6 week clipping intervals resulted in dry matter yields of 5.1, 6.9 and 8.9 tons/A, respectively.

Plants harvested at earlier growth stages are higher in nutrients such as nitrogen (N), potassium (K), and sulfur (S) since all three are involved with protein formation. As the crop grows older and dry matter increases, the nutrient content is diluted on a per ton basis. In the Georgia study, each ton of forage contained about 50 lb of N, 12 lb of P_2O_5, and 47 lb of K_2O. Thus, each acre of bermudagrass harvested at a 4-week interval and yielding about 7 tons/A would remove about 350 lb of N, 85 lb of P_2O_5, and 330 lb of K_2O. Also, about 25 lb of magnesium (Mg) and 40 lb of S would be removed.

Removal of Soil Nutrients without Adequate Replacement Can Be Costly

Annual crop fertilization is essential to maintain a productive stand of quality forage year after year. Nutrient management research shows that annual fertilization is beneficial in a given field for any one of the following reasons:

- To avoid a decline in stand due to severe winter injury or competition from weed species which are more competitive at lower soil nutrient levels. Early stand loss means fewer years to absorb high establishment costs and an increase in the cost per ton of forage. Georgia studies revealed that severe winter temperatures after the third harvest year resulted in stand survival of 76 percent for plants treated with a 2:1 N/K fertilizer. This compared with 35 percent stand survival where N was applied alone at 400 lb/A/year and 46 percent stand survival when 50 lb/A of K_2O was added to the 400 lb/A N application (**Figure 1**).
- To minimize disease problems brought on when crops are under stress from a nutrient shortage of K or from an imbalance among nutrients such as N, K and/or S. Researchers in Texas and Louisiana confirmed that K deficient hybrid bermudagrass is more susceptible to the fungal leaf spot disease, *Helminthosporium*.
- To avoid losing crop stress resistance due to drought, temperature extremes, frequent harvest, or injury from pests and diseases
- To prevent an early decline in both forage yield and especially forage quality. This results in lower feed value of each ton of forage (quality) plus more acres to produce the tonnage requirements.

Why Is the Right Balance of N, P and K So Important for Bermudagrass?

USDA and University of Georgia scientists provided the following answers from years of intensive work with common and Coastal bermudagrass treated with four levels each of N, phosphorus (P), and K, managed for optimum yield and quality forage.

- Both P and K fertilization increased the percentage of N recovered in the harvested crop.
- NPK fertilizer significantly increased the weight of roots to a depth of 3 ft. for Coastal. Root reserves and rooting depth are critical for rapid regrowth after harvest and for improved tolerance to summer drought stress.

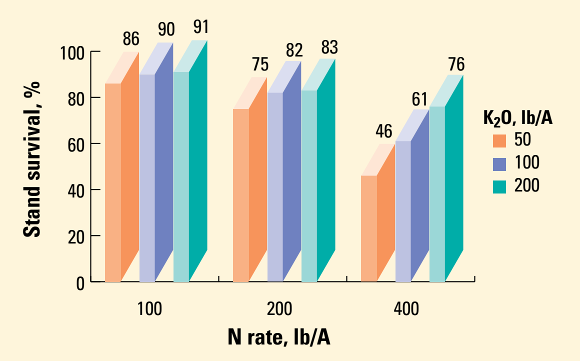


Figure 1. Influence of N and K on stand survival of Coastal bermudagrass. (USDA-ARS, Georgia)

- Total root weight increased from 3,440 lb/A in control plots to 6,858 lb/A due to annual fertilization with 400-200-200 lb/A N-P_2O_5-K_2O, respectively.
- Soil water used per ton of Coastal decreased from 9.8 inches in the control to 2.7 inches per ton of forage produced due to annual fertilization with the 400-200-200 treatment. No water was measured moving below the fertilized root zone.
- Yield of Coastal responded little to applied P when K was inadequate, regardless of the level of N applied. Forage yields increased with K fertilization at all levels of N and P. Coastal fertilized with 400-200-200 lb/A N-P_2O_5-K_2O yielded 7.3 tons/A compared with 5.9 tons with N and K but no P and only 5.7 tons/A when K fertilizer was omitted.
- Stand loss and the need for re-establishment are often the consequences and accumulative effect of inadequate K nutrition or an imbalance among N, P and K.

Fertilizer Scheduling Improves Forage Yield and Quality, Input Use Efficiency, and Stand Longevity

The timely application of the right nutrients in the right amounts is fundamental to nutrient management of any crop. Consider the following guidelines when growing bermudagrass as a high quality feed for livestock.

- Estimate the number of acres needed to produce an adequate supply of high quality livestock feed.
- Select highly productive fields and soil test to determine lime and build-up P and K needs. Incorporate lime and nutrient needs before crop establishment.
- Consider preplant applying up to half of the N and K plus all other remaining first season nutrient needs.
- Split apply the remainder of first year N and K as well as subsequent year annual maintenance fertilizer needs. Options include the resupply of nutrients after each crop harvest, or splitting annual needs with about one-half going on after the first cutting in the Spring and the remainder after the next to last harvest in the Fall. The objective is to stimulate rapid regrowth, provide full-season nutrient needs, attain optimum nutrient use effectiveness and avoid premature loss of stand.
- Nutrients most often needed to maintain quality forage include N, P, K, S, Mg and boron (B). Field studies, in general, show that total nutrient needs for maintenance are quite comparable to the amounts removed in the harvested forage at that site.

Visible nutrient deficiency symptoms are seldom seen on leaves of high yielding bermudagrass plants. Early warning signals might include one or more of the following:

- slow plant regrowth after harvest
- disease problems, such as leafspot
- premature decline in stand
- poor response to applied N, possibly due to a shortage of S or K
- winter injury
- low or declining protein or TDN
- low forage digestibility or palatability for livestock
- weed infestations
- low or unusual nutrient content in the leaves. BC

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COLORADO

Variability of Phosphorus Over Landscapes and Dryland Winter Wheat Yields

By R.A. Ortega, D.G. Westfall and G.A. Peterson

The use of variable rate fertilizer technology (VRT) is receiving considerable attention. It offers potential benefit to the economics of agricultural production and potential minimization of adverse environmental impacts caused by improper rates of fertilizers and agricultural chemicals in general.

Because of the spatially continuous nature of landscapes and soil formation processes, it is not unreasonable to expect that soil measurements taken in proximity to each other would be related to themselves and to variations of other parameters or properties of the landscape.

Yield and yield response to fertilizer depend not only on soil nutrient level, but also on other growth limiting factors. In recent Colorado studies, soil test phosphorus (P) levels did not necessarily predict wheat yield response to P fertilizers. A "multivariate" approach is necessary to predict yield response.

We have been conducting research to quantify the spatial variability of soil test P, other selected soil properties, and winter wheat grain yields over typical dryland landscapes in the central Great Plains.

Field Study

This experiment was conducted at two field locations in eastern Colorado – Sterling and Stratton. Dryland winter wheat, fertilized with five P rates (0, 12, 23, 34, and 46 lb P_2O_5/A, band applied as 10-34-0 with the seed) was planted in parallel strips over the landscapes. At Stratton only two P rates (0 and 46 lb P_2O_5/A) were used. For nitrogen (N) fertilization, 46 lb N/A as UAN solution was applied to all treatments. The elevation differences within the landscapes were 18 and 12 ft. at Sterling and Stratton, respectively. This topographic relief is typical of the central Great Plains. We soil sampled and determined yields at 73 and 35 positions (every 20 ft.) from the Sterling and Stratton landscapes, respectively.

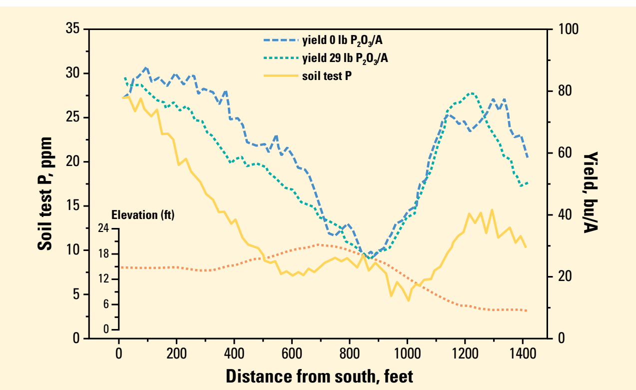

Figure 1. The variability in $NaHCO_3$-P and yield of dryland winter wheat over the Sterling landscape. Lines represent kriged values.

Variability of Soil Characteristics (0-4 inches)

The $NaHCO_3$-P concentrations varied from 1 to 31 parts per million (ppm), shown in **Figure 1**. The $CaCO_3$ varied from zero to almost 2 percent C, pH from 5.7 to 8.5 (**Figure 2**). Organic matter varied from 1.19 to 2.03 percent while inorganic N (NO_3-N plus NH_4-N) varied from 12 to 32 ppm across the landscape at the Sterling location (**Figure 3**). Positions with low P levels also had high levels of $CaCO_3$, high pH, and low organic matter. Similar variations in soil properties were found at the Stratton location. The range (distance at which samples become independent) was 590 ft. for inorganic N and less than 531 ft. for all other soil properties. All soil properties showed high spatial dependency (positive autocorrelation), which allowed kriging models to accurately predict our variables.

Yield Variability

Dryland winter wheat yields varied from 14 to 97 bu/A, depending on landscape position and P rate at Sterling (**Figure 1**). Grain yield showed a strong spatial dependency which resulted in high coefficients of determination (R2 = 0.88 to 0.92) using kriging models. The range of spatial dependency for yield averaged 304 ft., somewhat similar to those other soil properties.

At the Stratton location (data not shown), wheat grain yields varied from 17 to 90 bu/A. Yields showed a high spatial autocorrelation, therefore kriging models predicted our data very well. The average range of spatial dependency for grain yield was 217 ft.

Grain yield at 42 percent of the sampling locations along the Sterling landscape responded to P fertilization. Seventy-two percent of all these positions were below 14 ppm $NaHCO_3$-P [the current P critical level (CL) for Colorado.] However only 38 percent of those below the CL responded to P application (**Figure 1**). Similarly, 28 percent were above the CL and 50 percent of those above the CL responded to P fertilization. Similar results were observed at Stratton. On the average, the current CL that divides responsive from non-responsive soils failed 59 percent of the time.

The Big Question

"Why didn't soil test P more accurately predict yield response to P fertilizer?" These results point out an important, and long understood, relationship but one that many of us working in soil fertility often forget or disregard. That is, plant response is often limited by factors other than nutrient availability. In our studies, the response to P fertilizer, and ultimately dryland winter wheat grain yields, did not depend solely on the P soil test level, but several other growth limiting factors. For example, at the Sterling location, some low yielding positions in the land-

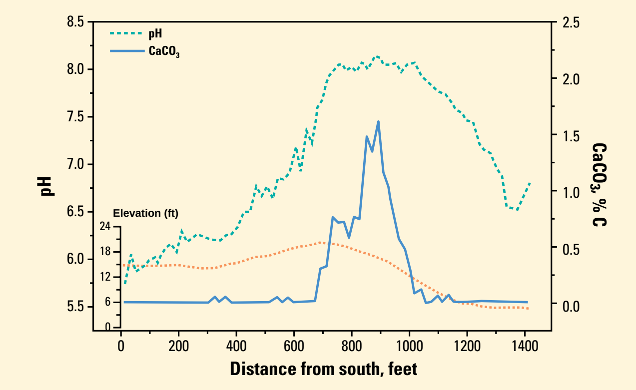

Figure 2. The variability in soil pH and free lime ($CaCO_3$) over the Sterling landscape.
Lines represent kriged values.

scape did not respond to P fertilization, although their P levels for the positions were very low (800 to 1,000 ft. in landscape, **Figure 1**). These positions had low organic matter and residual soil N levels, contained free lime and were highly eroded landscape positions. Over the years most of the topsoil had been lost by erosion. Therefore, shallow topsoil and low water holding capacity were probably the most limiting growth factors. No rate of fertilizer P would result in an increase in grain yield even though soil test-P levels were very low.

Relationship Between Winter Wheat Grain Yields and Soil Properties

Grain yield always correlated with all measured soil properties, either positively or negatively. In other words, the soil properties we measured explained only part of the yield variation, but not all of it. If we used only one single variable (for example $NaHCO_3$-P) to predict yield and response to fertilizer application, this model often failed. A multivariate approach must be used to overcome this problem because other factors are limiting yields.

We performed a principal component analysis on both sites to better describe and separate the different landscape positions by using "indices" representing an integration of soil properties. At Sterling and Stratton, the principal component 1 ("soil index 1") explained 70 and 94 percent of the total yield variance, respectively. Soil organic matter and organic N, extractable-P, and moisture influenced the principal component 1 value positively in contrast to the negative influence of lime content and pH. Similar results were obtained for Stratton. This multivariate approach was successful in predicting yield response over the landscape with soil test-P being only one component of the response model. This points out the importance of considering all the production factors we recognize as yield limiting, when using VRT systems. A single soil test measurement will not give consistent, reliable results.

Conclusions

Soil properties and dryland winter wheat yields varied widely across landscapes. Most measured variables were highly autocorrelated, which allowed kriging models to predict soil parameters and yields accurately.

Response to P fertilization was erratic in both landscapes. Soil test-P levels did not necessarily predict response to P fertilizer. Other growth limiting factors often controlled response to P fertilizer.

All measured soil properties were highly correlated with yields. Yields were a function of soil properties that can be represented by principal component analysis, i.e., considering all the factors we recognize as yield limiting in a particular field.

Our results demonstrate that a multivariate

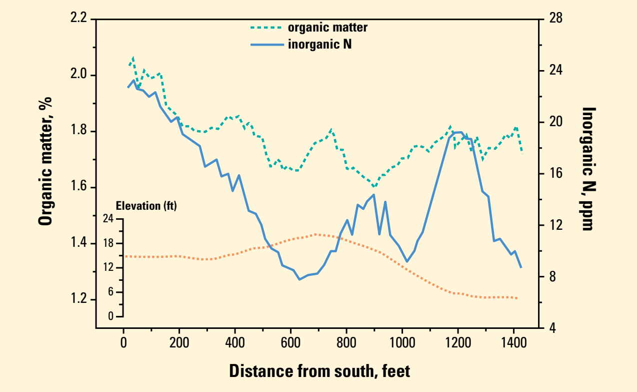

Figure 3. The variability in soil organic matter (OM) and residual soil inorganic N (NO_3-N+NH_4-N) over the Sterling landscape. Lines represent kriged values.

approach to nutrient recommendations is required, since yields and yield response to fertilizer are not only dependent on the soil nutrient level but other growth limiting factors. Other production parameters need to be considered when making VRT fertilizer recommendations based on soil test level. The big question is: "What are these factors and can we control or modify them"? Until the controlling "soil factors" are identified and understood, maximum benefit of VRT is not possible and inconsistent results of VRT will be obtained. BC

Dr. Ortega is a former Graduate Research Assistant, Dr. Westfall and Dr. Peterson are Professors, Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO 80523. (Dr. Ortega is now an agronomist with INIA in Chile.)

E.T. York Honored as a "Great Floridian"

Dr. E.T. York, chancellor emeritus of Florida's state university system and a distinguished service professor emeritus at the University of Florida's (UF) Institute of Food and Agricultural Sciences, has been designated as a "Great Floridian" by Florida History Associates, the direct support organization of the Museum of Florida History in Tallahassee. This honor has been bestowed on only 11 other Floridians who have made notable contributions in shaping the state of Florida.

A native of Alabama, Dr. York joined UF in 1963, where he served as vice president for agricultural affairs, executive vice president and interim president. In 1975, he became chancellor of Florida's state university system for five years, retiring early to pursue his long-term interest in global hunger and Third World development.

Included among Dr. York's numerous awards are the President's Voluntary Action Citation presented by President Reagan; the "Service Above Self Award" of Rotary International, the highest recognition accorded a Rotarian; and a citation issued by the National Association of State Universities and Land Grant Colleges recognizing "his inspired leadership in mobilizing the resources of our universities in the ongoing struggle against poverty and hunger throughout the world."

He was appointed to prominent advisory positions by Presidents Kennedy, Johnson, Nixon, Carter, Ford and Reagan, by various foreign governments and by a number of U.S. governmental agencies. Dr. York received his bachelor's degree in agricultural science and his master's degree in soils/agronomy, both from Auburn University, and his Ph.D. in soils from Cornell University.

Dr. York was Eastern Director of the American Potash Institute in the late 1950s and served on the board of directors of the Foundation for Agronomic Research (FAR) in the 1980s and early 1990s. All of us at PPI and FAR proudly congratulate him for being named a "Great Floridian". BC

MISSOURI

Soil Fertility Affects Establishment and Persistence of Red Clover in Grazed Pastures

By Jim Gerrish

Interseeded legumes play an integral role in pasture improvement programs in the humid-temperate region of the U.S., but producer success with overseeding legumes in grazed pastures has been quite variable. Soil fertility may be one factor affecting establishment and subsequent persistence of overseeded red clover. Numerous small plot studies have addressed questions of legume response to soil pH, P and potassium (K) levels. Less information is available regarding plant response in grazed situations.

> Forage grass and red clover components in grazed pastures were evaluated relative to the soil fertility status of the pasture. Soil phosphorus (P) appears to be a critical factor in establishment and maintenance of red clover in grazed pastures.

We conducted a study at the University of Missouri-Forage Systems Research Center located in north-central Missouri to evaluate the effect of soil pH, Bray P-1 and exchangeable K on the establishment and persistence of red clover overseeded into forage grass pastures. Eight pastures...four in smooth bromegrass and four in orchardgrass sods...were subdivided into three paddocks for rotational grazing. One 5.33-acre paddock from each base pasture was used, providing four replicates of each base grass sward.

Within each sample paddock, five transects were established originating at the water source. Another objective of this study was to measure the transfer of soil nutrients by grazing animals, thus the sampling transects were placed relative to stock water location. Permanent sampling sites, approximately 2 yards square, were established along each transect at 100-ft. intervals. Due to variance in paddock shape, the number of sample sites in each paddock ranged from 26 to 33. At each sample site, soil samples were collected from a one yard square quadrant each September for four consecutive years. A different quadrant of the 2-yard square sample site was used each year to avoid any effect the sample probe holes may have had on water or nutrient movement to deeper soil strata. Samples were taken to a 6-in. depth and were divided into 0 to 3 in. layer and 3 to 6 in. layers. At the same time soil samples were collected, red clover stand was assessed by two methods. Visual estimates of ground cover percentage of red clover, base grass, and bare ground were made when the clover had regrown to approximately 4 in. during the rest period. Individual mature plants and red clover seedlings were also counted within a one square yard quadrant. The same two methods of red clover stand evaluation were used in mid-April at all sample sites.

While individual paddocks differed in mean soil fertility levels and red clover population, smooth bromegrass and orchard-

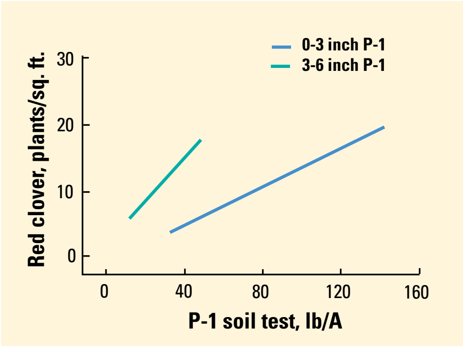

Figure 1. Impact of P-1 soil test level on mature red clover plant population present in grazed pastures in late summer.

Note: The equations which describe Figure 1 follow.

1.55 + 0.339*x; R-sq. = .40 (3-6 inch P-1)

-0.39 + 0.143*x; R-sq. = .29 (0-3 inch P-1)

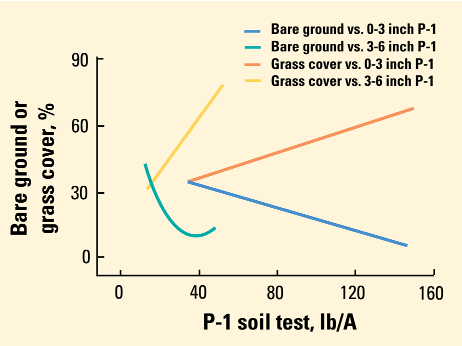

Figure 2. Impact of P-1 soil test level on bare ground and grass canopy cover in grazed pastures during late summer.

Note: The equations which describe Figure 2 follow.

45.4 - 0.275*x; R-sq. = .29 (Bare ground vs. 0-3 in. P-1)

85.4 - 3.91*x + 0.051*x^2; R-sq. = .38 (Bare ground vs. 3-6 in. P-1)

24.05 + 0.346*x; R-sq. = .23 (Grass cover vs. 0-3 in. P-1)

16.99 + 1.33*x; R-sq. = .51 (Grass cover vs. 3-6 in. P-1)

grass paddocks did not differ in any of the measured parameters. Data were pooled across all eight paddocks for regression analysis of soil and sward characteristics.

Spring sward measurements of grass and clover components were not highly correlated with any soil parameters. Spring grass cover increased slightly in response to higher exchangeable K levels in the 3 to 6 in. layer, but neither red clover plant population nor estimated ground cover was significantly affected by any soil variable. Spring clover populations appear to be more affected by severity of winter weather and grazing pressure during the previous fall and winter rather than by soil fertility.

Red clover seedling plants, mature plants, and estimated ground cover were all significantly affected by soil variables at the September observation date. Clover seedling number increased significantly as pH in the 0 to 3 in. layer increased above 6.0, indicating that the soil environment for seedling establishment may be improved by surface lime application. Observed bare ground percentage decreased linearly with increasing pH in the 0 to 3 in. layer. The range of observed soil pH was from approximately 5.6 to 6.8. This range in pH may not have been great enough for a measurable increase in red clover population due to increasing soil pH.

Soil P had the greatest impact of the measured soil variables on most sward parameters (**Figures 1 and 2**). Both grass cover and mature red clover plants measured in September increased linearly as P in both the 0 to 3 and 3 to 6 in. layers increased. Estimated red clover ground cover increased at a more rapid rate as 3 to 6 in. P increased compared to 0 to 3 in. P. This response may be due to more extensive rooting at greater depths as 3 to 6 in. P increased. Two of the four years of this study had below normal rainfall during the July to September period. We believe that deeper roots due to higher P levels may have offset some drought stress.

Visual estimate of red clover canopy cover was not highly correlated to soil fertility parameters. Number of mature plants in the sward appears to be a better indicator of pasture fertility status than does visual estimate of canopy cover.

A surprising result was a highly significant response of mature red clover plants to increasing exchangeable K levels which indicated declining plant numbers at higher levels of K. The higher levels of K are far below any potential toxicity level, so the result was initially confusing. However, as these data are sample site-specific, the cause of this response is easily explained. In this same grazing study, soil nutrient redistribution by grazing livestock was also measured. Almost all of the sample sites with K soil tests in excess of 400 lb/A exchangeable K were within 150 ft. of watering sites. These sites also had the highest bare ground estimates and lowest grass canopy cover estimates, probably due to overgrazing and soil compaction in these areas. Thus, while red clover plant population initially increased in the general grazing areas as K levels increased, the declining plant population at higher fertility levels is in response to grazing factors, not soil fertility. The red clover population response to soil K described above is one of the reasons why it is important to study forage fertility responses in the pasture environment, not only in small plot settings.

In summary, soil P appears to be a critical factor in establishment and maintenance of red clover in grazed pastures. Red clover plant population increased linearly as soil P increased throughout the range of Bray P-1 values measured in this study. Even though red clover plant population increased at higher P levels, dry matter yield has been shown to peak at much lower soil P levels. BC

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Aglime Facts Booklet Now Available

Agricultural lime (aglime) can be a valuable part of nutrient management for profitable crop production systems. Correcting acid soil conditions and maintaining optimum soil pH range are keys to achieving best results with nitrogen (N), phosphorus (P), potassium (K) and other essential nutrients in crop and forage production.

A new booklet...prepared jointly by the Potash & Phosphate Institute (PPI), Foundation for Agronomic Research (FAR), and the National Stone Association (NSA)...offers a useful overview of considerations on aglime. While not an "in-depth" reference text, the 16-page booklet discusses several topics, including: the importance of aglime in agriculture; why soils become acid; determining aglime needs; aglime quality and types; aglime and crop production; and applying aglime. Color photos and charts help illustrate responses and benefits of aglime.

The *Aglime Facts* booklet is available at $2.50 per copy (reduced price of $1.25 each for member companies of PPI, contributors to FAR, schools, and government agencies)...plus shipping cost. To order or for more information, contact:

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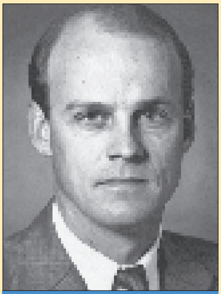
Robert E. Wagner Award Recipients Announced

Two outstanding agronomic scientists have been selected to receive the 1996 Robert E. Wagner Award by PPI. The Award encourages worldwide candidate nominations and has two categories...one for a senior scientist and one for a younger scientist under the age of 40. The recipient in each category receives a monetary award of US$5,000.

Prof. Lin Bao

Professor Lin Bao of the Soil and Fertilizer Institute (SFI), Chinese Academy of Agricultural Sciences (CAAS), was selected in the senior scientist category. Dr. William R. Raun, Department of Agronomy, Oklahoma State University, receives the honor in the young scientist division.

The Robert E. Wagner Award recognizes distinguished contributions to advanced crop yields through maximum yield research (MYR) and maximum economic yield (MEY) management. The Award honors Dr. Wagner, President (Retired) of PPI, for his many achievements and in recognition of his development of the MEY management concept...for more profitable, efficient agriculture.



Dr. William R. Raun

"With nominations received from throughout North America and other parts of the world, selection of these two individuals represents a global honor," said Dr. David W. Dibb, President of PPI. "The standards for this award are high, and those chosen are truly deserving of the recognition."

Dr. Lin is Director (Retired) of SFI in Beijing, People's Republic of China, and continues working in agronomic science and technology transfer by guiding Ph.D. students in research studies and serving on executive committees of several scientific societies in China. During the past 35 years, he has made a substantial contribution to plant nutrition research and educational activities in the areas of soil fertility, plant nutrition, and balanced fertilization. In the late 1970s, he became the leader of the China National Network on Evaluation of Chemical Fertilizer Use (CNNECFU), a national research network organized by the Ministry of Agriculture and CAAS. The results of this work have provided a scientific basis for China to guide the production, importation, distribution and application of mineral fertilizers.

Dr. William R. Raun is Associate Professor at Oklahoma State University, Stillwater, and directs the Soil Fertility and Plant Nutrition Research Program in the state. He is widely recognized as a leader in soil fertility research, and is distinguished in the application of statistics for interpretation of research, especially as related to long-term field studies. He has recently been involved in pioneering work in the development of sensor-based technology for real time precision farming in the application of variable rate nitrogen top-dressing on winter wheat and bermudagrass. New technology related to Dr. Raun's recent research could lead to increased yields by eliminating nutrient deficiencies in all areas of a field while avoiding over-application in some areas. BC

Prestige

A grandson soon will enter college. We discussed agriculture as a profession. Apologetically he said, "But there's no prestige in agriculture."

Just what is prestige? I draw upon the "words of Martin", a modest, humble, yet brilliant close friend.

Webster says something about prestige being the power to command admiration through unusual achievement or reputation. But the Romans, from whom the French passed on their version to Webster, called it an illusion, a juggler's trick, a delusion.

Is it the absurd idea that one who works with his hands and wears a blue collar instead of white is less prestigious – thus creating a shortage of reliable hands to feed the world and to fix our cars and our commodes?

Credentials – awards – plaques – titles – so numerous these days that wall space is crowded. And the ultimate – a listing in the "Majestic Order of Universal Notables". Fill in the blanks and order the directory at 80 bucks.

Prestige – where is it when the stabbing pain in the chest comes, arteries growing thick and tired, the dreaded word cancer?

When they bring us gently to the turf, how hollow are the degrees, the money, the social standing, the "prestige". It's what they say about our character – and the premium God Almighty puts on that credential. There will be a few well meaning friends extolling "the great man" to the sharp discomfort of his poor soul somewhere out there lying prostrate before the Power of all powers.

Maybe my grandson is right. There's no prestige in agriculture. Just an opportunity to contribute and to serve.

J. Fielding Reed

BETTER CROPS
WITH PLANT FOOD

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