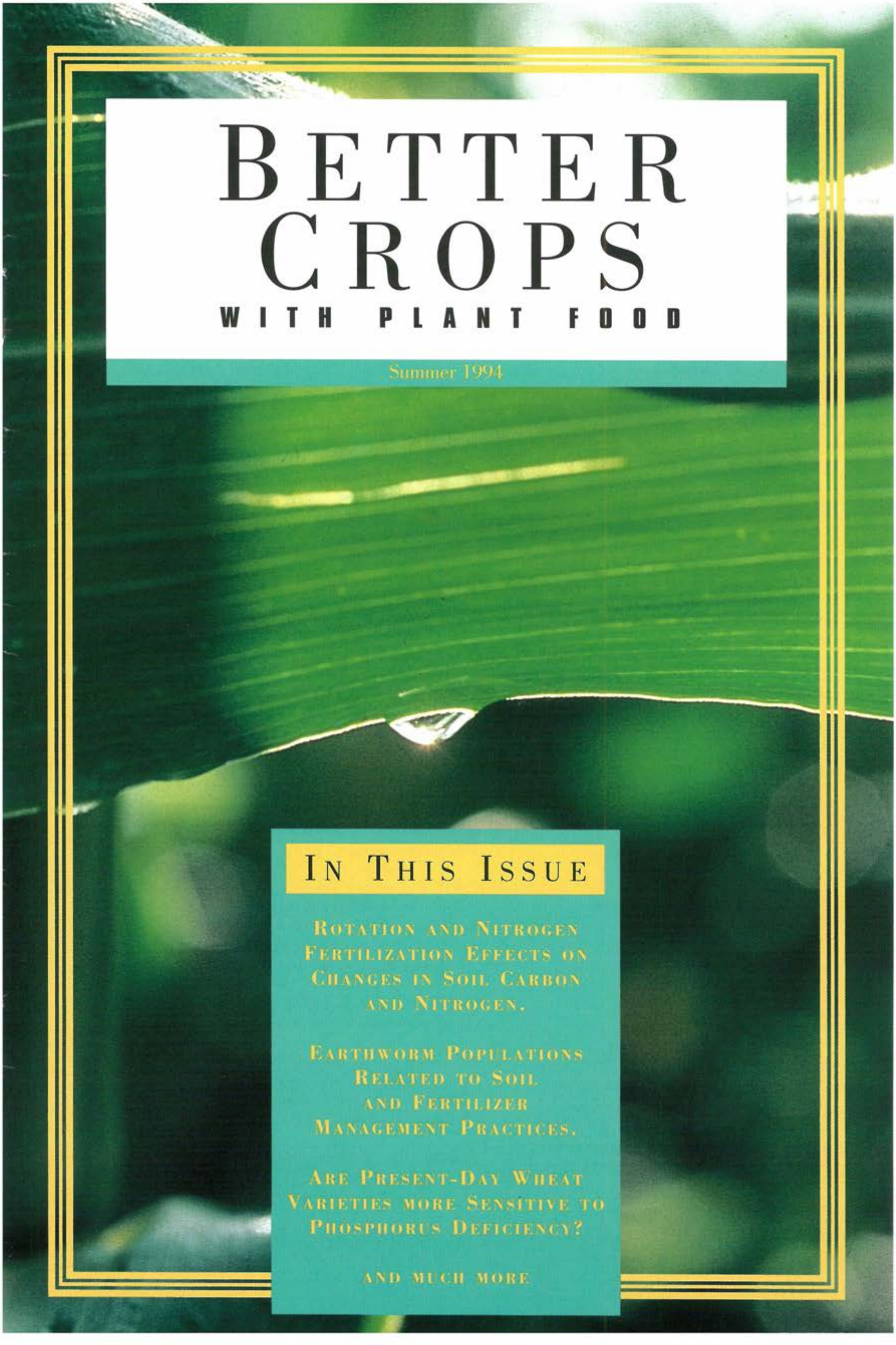

BETTER CROPS
WITH PLANT FOOD

Summer 1994

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AND MUCH MORE

BETTER CROPS
WITH PLANT FOOD

Vol. LXXVIII (78), No. 3 Summer 1994

Our Cover: Moisture glistens on a corn leaf.
Photo Credit: Harlen Persinger
Design: Rick Robbins Design

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The Impending "Phosphate Pollution Crisis"... One Man's Opinion

By K.L. Wells

I HAVE BEEN LISTENING and reading for the past couple of years or so about the dire consequences that this nation will face unless we do something about the phosphate contamination of our surface and groundwaters from agricultural practices. I'm led to believe that such contamination is taking place because farmers are: 1) overusing phosphate fertilizers, 2) overloading soils with applications of animal manures, 3) allowing excessive erosion of surface soils, and 4) using conservation tillage practices.

These "concerns" are being manifested in calls for more research on understanding and abating the contamination practices, and for more regulatory measures to enforce or encourage practices designed to control use of animal manures and phosphatic fertilizers and to minimize soil erosion. The USDA's Soil Conservation Service (SCS) has already developed a "phosphorus index" for the nation's soils and is in the process of implementing this index into their Technical Guides. The October 1993, issue of *Water Quality Technology Notes,* a SCS newsletter, states:

> "PHOSPHORUS INDEX: The technology of the Phosphorus Index has been released to the four National Technical Centers for their development of a regional technical note. The technical notes will be the basis for incorporation of the technology into the Field office Technical Guide. The Phosphorus Index is a matrix tool that can be used to assess the potential for phosphorus movement from a landscape or field site. The process uses readily-available field data to rate the site condition for potential phosphorus movement, or loss."

As a person who has lived and worked as an Extension soil scientist in a naturally "high phosphate" environment for the past 25 years, I have been somewhat bemused by all this "concern." I feel this way because of my observations and experience in Kentucky's Inner Bluegrass, a physiographic area in which dominant upland soils have developed in place from phosphatic limestone rocks of the Ordovician period. Indeed, soil tests from such soils show that they commonly contain 100 to 500 parts per million (ppm) of available phosphorus (P), have been in that range since the advent of soil testing, and remain there even without use of commercial phosphatic fertilizers. In fact, the underlying limestone at some sites within this area is high enough in P that it was mined years ago for extraction of phosphate. The Central Basin of Tennessee is a similar area.

In checking research results from studies at the University of Kentucky during the past 10 to 15 years, it appears that the soluble phosphate-P content of groundwater and streams in Kentucky's Inner Bluegrass Area is generally within the range of 0.1 to 0.5 ppm, and commonly may contain 0.3 to 0.4 ppm. These levels, I'm told, can result in eutrophication of surface waters. In fact, eutrophication of many streams and ponds commonly occurs in Kentucky's Bluegrass Regions,

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particularly during the summer. Apart from the unsightliness of scum on a pond or aquatic plant growth in ponds and along the edges of some creeks, it has not been apparent to me that we have a "problem" due to phosphate content of our water in this area. In fact, the Bluegrass area is widely considered to be one of the more picturesque agricultural landscapes in the nation, producing many of the nation's best thoroughbred horses. It is also an important region for production of many breeds of fine beef cattle. I am also unaware that there are either economic or health problems in treatment of streamwaters and municipal reservoir waters in this region due to phosphate content or eutrophication. I pay $2.75 per 1,000 gallons for water taken from the Kentucky River by a commercial water company. The water is treated, and piped into my home, and the price seems to me rather reasonable for high quality water.

In plain words, despite living and working in an area that is contaminated with phosphate by nature, I fail to grasp the urgency and need for such a "national concern" about phosphate content of water. As a matter of fact, I find it somewhat contradictory in that a huge amount of taxpayers' money has been spent by our government to stop erosion, and that the U.S. Farm Bill now requires participants in USDA farm programs who farm "highly erodible" lands to use it according to conservation plans which encourage and often require "residue management" practices. And now, these participants are being told that such practices increase phosphate content of water runoff. This fact has been confirmed by our own research here at the University of Kentucky. However, total volume of surface water runoff is greatly reduced by "residue management" practices. Because of this, the actual amount of phosphate lost in surface runoff from fields in conservation tillage systems, especially no-till, is only a fraction of that lost from clean tilled fields even though the phosphate concentration of that runoff can be much higher. So, why the concern about the high phosphate concentration in surface runoff from fields receiving little or no tillage?

As to whether farmers are overusing commercial phosphatic fertilizers, tonnage figures show that such use has peaked and is declining in the U.S. Based on soil test summaries, it is apparent that some farmers have used commercial P fertilizers during past 40 years to enrich the plow layer of many fields from low to high levels of available P. However, since inorganic phosphates have very low solubilities, their loss from dissolution in surface runoff or leaching of water has never been considered to be of concern except for that contained in the sediment load during soil erosion.

Phosphorus in animal manures is another story. It has long been recognized that the use of animal manures adds to and enhances the availability of residual soil P due to phosphorus being retained in organic molecules which are more water soluble than inorganic phosphates. The concentration of large numbers of animals in some localities has generated large amounts of manure which are stored and spread locally. This sometimes results in overloading of manure on nearby fields, and sometimes results in storage facilities washing or overflowing directly into streams and ponds. It is not unreasonable to expect that phosphate content of surface runoff and groundwaters would be increased by the presence of large volumes of organic P in manure. While this represents a pervasive problem to individual operations or localities where concentrations of such operations exist, it by no means represents U.S. animal production systems in general. For this reason, it would seem appropriate to me that plans for regulation of manure storage and disposal be directed to such operations and localities rather than a state or the nation as a whole. Rumors about this situation abound, but one I've heard being considered in a nearby state would prohibit spreading of manure on any soil testing higher than 30 ppm available P. Such a regulation here in Kentucky's naturally highly phosphatic Inner Bluegrass would decimate animal production in the region.

The main idea I've tried to present here is that, in my opinion, non-point source phosphate contamination of groundwater and surface water deserves a much lower priority for national concern about the environment than it is receiving. Surely there are environmental concerns about water quality that deserve more national concern. For those who feel that a "high phosphate" environment is of paramount concern, I would invite you to visit Kentucky's Bluegrass or Tennessee's Central Basin regions and see for yourself what existence is like in a naturally high phosphate environment.

As an epilogue, I would point out that I do not advocate overuse of fertilizer, point-source disposal of manure, or soil erosion. What I'm really suggesting is use of some common sense in development of national issues to which regulatory responses can often unduly affect our nation's agricultural system.

I'll close with two challenges: 1) If there is a great nationwide concern about this situation by the scientific community, the Council on Agricultural Science and Technology (CAST) should be asked to develop a white paper assessing the situation to ascertain its importance. 2) Before implementing a "Phosphorus Index" for soils into its Technical Guides in the U.S., the SCS should widely field test this index and obtain "ground truth" of its validity and effects it may have on prevalent and recommended agricultural practices. ■

Oklahoma

Ammonium and Nitrate Nitrogen in Soil Profiles of Long-Term Winter Wheat Fertilization Experiments

OBJECTIVES OF THIS STUDY were to evaluate the long-term response of winter wheat to nitrogen (N) fertilization and to determine the accumulation of ammonium-N (NH_4-N) and nitrate-N (NO_3-N) in the soil profile.

Four long-term experiments (greater than 18 years) on soils that had received selected annual N fertilization were sampled. Soils were either silt loam or clay loam in texture. At each location, one soil core 1.75 inches in diameter and to a depth of 8 feet was taken from plots receiving variable N rates. Each core was segmented into 12-inch increments and analyzed for NH_4-N and NO_3-N. Results were as follows:

- At all locations, NH_4-N levels were not significantly different from the zero N treatment when N was applied at or below yield goal requirements (80 to 40 lb/A N). Similar results were obtained for NO_3-N.
- When N rates exceeded 80 lb/A, NH_4-N levels in the upper 6 inches increased above the zero N treatment, while there were no differences in subsurface layers. At the excessive N rate, NO_3-N did accumulate at depths greater than 12 inches.

In summary, researchers found that N accumulation . . . either as NH_4-N or NO_3-N . . . is not a problem in soils where recommended N fertilizer rates are applied. ■

Source: Westerman, R.L., R.K. Boman, W.R. Raun and G.V. Johnson. 1994. Agron. J. 86:94-99.

Potassium and Plant Stress in Turf

By Robert N. Carrow

Potassium (K) has an important role in turfgrass culture, especially on recreational sites. Fertilization recommendations for K on turf are based on maximizing tolerance to high temperature, low temperature, drought and wear stresses. On very sandy soils, nitrogen (N):K_2O fertilization ratios are often used to determine K rates rather than soil testing.

PROPER K fertilization is particularly important on recreational turfgrass sites where frequent traffic, close mowing, and high maintenance make the grass prone to environmental and wear stresses. Many sports turf sites have high sand root zone media that are low in K, while frequent irrigation and removal of clippings further deplete soil K. Even when the soil is fine textured, soil K may be low if the predominate clays are kaolinite, illite, or hydrous iron-aluminum oxides; if high rainfall has leached the K; if the soils are acidic with low content of base cations; or, if heavy cropping has depleted soil K levels.

Potassium and Plant Health

Potassium is an essential nutrient required in high amounts by turf plants; it ranges from 1 to 4 percent by dry weight of vegetative tissues. Many plant enzymes require K as a cofactor for their activation. The production of high energy adenosine triphosphate (ATP) in photosynthesis and respiration requires K. When K deficiency limits ATP, processes requiring energy from ATP are restricted, such as sugar translocation, N uptake, and protein synthesis.

Additionally, K plays a major role in plant water relations. Without sufficient K, plants cannot maintain adequate turgor pressure in vegetative tissues; leaf water potential declines; yet, stomata remain open, causing high transpiration. Stresses on turfgrasses that are especially sensitive to K are: a) drought, b) high temperature, c) low temperature . . . K is a major solute in the "hardening" of turfgrasses for drought and high/low temperature tolerances, and d) wear, physical injury from traffic induced pressure, tearing and scuffing. Wear tolerant tissues have high turgor pressure.

Avoiding excess salts is also important for turf management on sandy soils. Potassium and associated ions can increase soil salinity as well as cause foliar burn to vegetative issues if applied at too high a rate. Salinity is especially a problem on irrigated sandy soils in arid regions or during prolonged drought periods.

Complicating K fertilization of turfgrasses are the interactions between N and K. Both nutrients are required at relatively high levels on recreational turf and both influence turfgrass water relationships by several mechanisms.

Georgia Research

A study at Griffin, GA, on a 'Penncross' creeping bentgrass golf green, examined interactions of N and K. Nitrogen was applied at annual rates of 262 (average) and 394 (high) lb/A, while K_2O was applied at 0, 131, 262 and 394 lb/A. The K source was potassium sulfate (K_2SO_4) with split applications of 33 percent in March, 16 percent in June, 16 percent in late July, and 33 percent in September. The golf green soil was 96.7 percent sand, 2.3 percent silt, 1.0 percent clay and 0.84 percent organic matter.

As **Table 1** indicates, low K was most detrimental to visual quality in the summer at high N appplication rates and in the driest year, year 2. High K, however, also

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Table 1. Potassium and N interaction effects on visual quality of creeping bentgrass.

Rate, lb/A		Visual quality[1]				Relative clipping yield, %	
		Year 1		Year 2		Year 1	Year 2
N	K_2O	Jul	Aug	Jul	Aug	Aug	Aug
262	0	7.4	7.4	7.0	7.2	100	100
262	131	7.3	7.5	7.3	7.5	101	142
262	262	7.5	7.3	7.3	7.4	113	166
262	394	7.3	7.2	7.1	7.0	99	104
394	0	7.7	7.1	5.4	5.7	113	79
394	131	7.5	7.1	7.0	6.9	106	141
394	262	7.6	7.0	7.0	7.1	137	200
394	394	7.5	6.6	5.6	5.7	121	98

[1]9 = ideal; 1 = no live turf.

caused visual quality to decline in the driest year when N was high. Clipping yield data reflected the same N-K_2O trend responses. **Table 2** shows that when drought stress was imposed, wilt symptoms were highest at low K, especially in conjunction with high N.

These shoot responses were related to deep rooting and water extraction. As K application rates increased, deep rooting increased up to 262 lb/A K_2O at 262 lb/A N and to 131 lb/A K_2O at 394 lb/A N, then rooting declined. Thus, applied K improved deep rooting up to a point, then it declined. When high N was applied, this trend occurred at a lower K rate than when a lower N rate was used.

In year 1, all treatments exhibited higher root length density than in year 2, and deep water extraction was not strongly influenced by K. **Table 2** also shows that deep water extraction did decrease as N rate increased. However, in year 2, deep water extraction improved as K application increased, but then declined, especially under the high N level.

In the second year of the study, at the high N rate, wilt tended to decrease as K increased, but then went up at the highest K level. This trend was observed at other wilt readings in this study. A possible reason could be the buildup of salts within the root zone which could reduce water uptake. This often happens in arid regions on sand greens unless extra water is applied for leaching . . . and year 2 of the study was an unusually dry summer.

Turfgrass Recommendations

A common observation on recreational turfgrasses grown on high sand soils is that soil K levels always test low due to

Table 2. Potassium and N interactions on wilt, deep root growth, and deep water extraction of creeping bentgrass.

Rate, lb/A		Wilt, % / plot		Root length density 4 to 8 inch depth, cm/cm^3		Water extraction, 4 to 8 inch depth[1], inches H_2O	
N	K_2O	July Year 1	August Year 2	July Year 1	August Year 2	July Year 1	August Year 2
262	0	18	20	0.32	0.17	0.33	0.23
262	131	10	20	0.44	0.26	0.30	0.27
262	262	6	13	0.52	0.31	0.33	0.22
262	394	6	10	0.34	0.23	0.34	0.20
394	0	25	30	0.44	0.10	0.28	0.19
394	131	12	23	0.52	0.17	0.29	0.25
394	262	6	13	0.41	0.14	0.27	0.16
394	394	6	23	0.40	0.13	0.25	0.15

[1]Water extraction over 2 days from 4 to 8 inch root zone depth.

leaching and/or clipping removal. On all other soils, soil testing is the best means of evaluating K needs, but on sandy soils, turf managers often determine K needs based on applied N. Some also use tissue tests to monitor plant K levels.

Under Georgia climatic conditions, recommendations on high sand sites for all recreational turfgrasses are:

- When fertilizing at 40 to 120 lb/A annual N, use a 1:1.5 $N:K_2O$ ratio;
- When fertilizing at 121 to 225 lb/A annual N, use a 1:1.0 $N:K_2O$ ratio;
- At above 225 lb/A annual N, use a 1:0.50 to 1:0.75 $N:K_2O$ ratio.

In the summer months, especially on bentgrass, excess fertilizer applications at any one time should be avoided. For salt type K carriers, 10 to 20 lb/A K_2O can be applied every 2 to 6 weeks to maintain adequate K. Slow release K sources are also being developed to allow less frequent applications.

For finer-textured soils, where soil tests are the best measure of K needs, recommendations normally account for the higher K needs of recreational turf versus general use turf. On these sites, the turf manager should not use the previous guidelines based on $N:K_2O$ ratios.

Potassium fertilization is also very important for winter hardiness of warm season turfgrasses. Many turfgrass managers apply a portion of the annual K in early to midfall prior to dormancy. Rates of 20 to 40 lb/A K_2O are recommended for this purpose. ■

Mississippi

Soil Sampling Band-Fertilized Fields

MANY COTTON FIELDS in the Mid-South receive band placement of fertilizers. The soil sampling procedure used to obtain representative samples for testing without a biased influence of the fertilizer band is an important consideration. A potassium (K) research project was initiated on a farmer field near Greenwood, MS, where K had been applied in a deep placed band below the drill for six years. Soil samples were taken (1) in the drill, (2) in 6-inch increments from the drill to the row middle, and (3) by random sampling. Random sampling resulted in soil test K levels similar to the average of values for samples taken from the drill to the row middle. Sampling only in the drill where fertilizer had been banded resulted in higher soil test K levels, shown by data in table. Soil sampling where cores were taken randomly–in the drill row, the row middle, and in between, in no set pattern–was adequate for sampling fields with band applied fertilizers. ■

Soil test K levels from three soil sampling procedures

	Sampling procedure		
Soil depth, inches	In band	Random	Band to middle average
	Soil test K level, lb/A		
0 to 6	234	140	147
6 to 12	111	78	72

Source: Dr. Jac Varco, Dept. of Plant and Soil Science, Mississippi State University, Mississippi State, MS 39762.

North Dakota

Earthworm Populations Related to Soil and Fertilizer Management Practices

By E. J. Deibert and R. A. Utter

North Dakota research is currently evaluating earthworm populations and survival under various tillage and management practices. Populations and survival are influenced by soil water, degree of tillage, residue cover, crop rotation and fertilizer management practices.

THE BENEFITS OF EARTHWORMS in the soil and potential effects on improved soil productivity have been recognized for a long time. Earthworms ingest a large amount of soil and organic matter each day and excrete altered materials (casts) that influence the chemical and physical properties of soil. Earthworm activity has been shown to increase soil aggregation, which improves soil structure, increases water infiltration, retention and availability to plants. Activity also increases soil aeration which promotes plant root growth, assists in decomposition of plant residues, aids the microbial mineralization cycles of nitrogen (N), phosphorus (P) and sulfur (S), and enhances availability of potassium (K) and micronutrients.

Earthworm populations have been severely reduced or eliminated in some dryland cropping areas as a result of excessive tillage and poor management practices. The increased emphasis on residue management, especially no-till, in farm plans to reduce erosion and runoff problems has initiated new interest in earthworms. Residue management practices that conserve soil water, provide a food source, provide surface cover and reduce soil disturbance are essential for earthworm survival.

North Dakota Studies

Recent research in North Dakota has focused on the evaluation of earthworm species and populations in farmer fields under different management and reduced tillage practices. Replicated 6-inch deep soil core samples were collected in 1991 at three sites to measure live earthworm and cocoon populations as influenced by surface cover, crop rotation and N fertilizer application. Adjacent grassland sites were also sampled for comparison. At these sites, only two species of earthworms were found: *Aporrectodea tuberculata* and *Aporrectodea trapezoides*. These species are red or gray in color, leave casts in the soil or on the soil surface, and form horizontal burrows in the A and B horizons of the soil.

Influence of Crop Residues

One site in northeast North Dakota was sampled in June, just after barley had emerged, to determine the influence of crop residue cover. This field was located on a Barnes loam soil with 3 to 5 percent slope which had been in continuous no-till barley for five years. As shown in **Table 1**, the number of live earthworms increased 1.5 times when the residue after planting was doubled.

More significant is the influence residue had on cocoon formation, which gives an indication of both previous adult sexual activity and potential earthworm activity. The number of cocoons found at this site was exceptionally high. As residue doubled, the number of cocoons increased 2.5

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Table 1. Earthworm populations as influenced by surface residue after planting a no-till field.

Variable measured	Percent crop residue after planting 40-45	80-90
	---- number per square yard ----	
Earthworms	71	106
Cocoons	204	514
Total	275	620

Langdon Research Center, Northeast ND, 1991

Note: The high residue cover was located in the combine straw-chaff row from the previous year and the low residue cover was located outside the straw-chaff row.

times. The ideal soil water, soil temperature and cover conditions with minimal soil disturbance enhanced cocoon formation by mature adults. The total population, assuming survival and cocoon hatching, increased from 275 to 620 per square yard, with a 100 percent increase in residue cover. This study demonstrates the dramatic influence of residue cover. It also demonstrates the dramatic influence producers can have on managing earthworm populations through reduced tillage and maintaining more residue on the soil surface.

Effects of Rotations, Previous Crop

A site in Southeastern North Dakota was sampled in October to determine the influence of rotation and previous crop on earthworm populations. The field was located on an Overly-Bearden silty clay loam soil, with 1 to 2 percent slope, which had been in a no-till crop rotation system for more than 10 years. A corn-soybean-small grain rotation was currently utilized at this farm site. The number of earthworms found was exceptionally high as a result of good management practices. An adjacent native grassland site contained 355 earthworms per square yard. **Table 2** indicates that although the number of cocoons did not vary greatly among the rotations, the earthworm numbers progressively increased, depending on the crop planted, with wheat similar to soybean and both greater than corn. This increase in earthworm numbers is probably a function of when soybean occurred

Table 2. Earthworm populations in various crop rotations under a no-till system.

Variable measured	1990-1991 crop rotation: Wheat-Corn	Corn-Soybean	Soybean-Wheat
	------number per square yard ------		
Earthworms	257	346	443
Cocoons	27	71	35
Total	284	417	478

Breker Farm, Southeast ND, 1991

in the rotation since the highest numbers were obtained where soybean was either the current or previous crop. Earthworms prefer residues with low carbon to nitrogen (C:N) ratios, an important factor to consider when trying to maintain high earthworm populations in a crop rotation.

Effects of N Fertilization

Another site in east central North Dakota was sampled in May after wheat planting to determine the influence of anhydrous ammonia applied the previous fall. This field was located on a Hamerly-Svea loam soil with 3 to 4 percent slope managed in a barley-wheat-oil seed crop rotation with a high surface residue reduced tillage system. The barley residue after planting provided 57 percent cover.

It appeared that the application of ammonia in September did not have any long-term adverse effect on earthworms or cocoons. **Table 3** shows the numbers found were similar to those found where no ammonia was applied. Application of ammonia in September may be at a time when earthworms are quite active and

Table 3. Earthworm populations in the spring after application of anhydrous ammonia.

Variable measured	Ammonia application date N rate lb/A: 0 N	Sept. 15 50 N	Nov. 1 50 N
	earthworm numbers ---------per square yard--------		
Earthworms	98	98	292
Cocoons	62	71	98
Total	160	169	390

Burchill Farm, East Central ND, 1991

RESEARCH shows that increased residue cover can have a positive effect on earthworm populations.

some short-term loss may occur, at least in the area of ammonia release. However, earthworms were apparently able to rebound by spring to the original levels in the field. It is interesting to note the large number of earthworms found, a three fold increase, when fall application of ammonia was delayed until November. Soil temperatures are considerably cooler by November and the earthworms move deeper in the soil profile and enter their aestivation (resting) period. Potential damage to earthworms from ammonia application may be eliminated during this period.

The stimulation or increase in earthworm number can be explained by the fact that earthworm growth and sexual activity are enhanced by a high N environment. In this case, the ammonia supplied additional N to a soil system with a large amount of surface and incorporated small grain residues having a high C:N ratio. The added N increased biological activity which enhanced earthworm growth and sexual activity to produce increased cocoon numbers and higher populations. For comparison, an adjacent grass site, predominantly bromegrass, contained a total of 257 earthworms per square yard which is much lower than the highest total number found in the reduced tillage field.

Summary

These preliminary data suggest that maintaining a high percentage of residue cover does indeed increase earthworm populations by creating an improved soil environment which is essential for their development and survival in dryland areas. The data also point out the importance of including a legume in the rotation to provide an N-rich or low C:N ratio residue in the cycle to stimulate earthworm populations. Although no definitive proof was found that ammonia reduced earthworm numbers, a delay in application time to when earthworms are inactive increased the positive effects of the application. The beneficial effect of ammonia N appears to be due to the resulting increase in N status of the soil. This may be an important management practice, especially in rotations that contain residues with mostly high C:N ratios. The increased use of management practices that stimulate earthworm populations will enhance soil tilth by improving the physical properties and nutrient availability of the soil. ■

Soil Fertility Manual Videotapes Now Available

VIDEOTAPES are now available to accompany the popular *Soil Fertility Manual*. PPI has prepared videotapes for each of the 10 chapters, varying from 15 to 25 minutes in length. The tapes are VHS format and are available by individual chapter at a cost of $20.00 each or as a complete set for $150.00.

Discounts are available to members of PPI, contributors to FAR, and to university and government agencies.

For additional information or to place an order, contact: Circulation Department, PPI, 655 Engineering Drive, Suite 110, Norcross, GA 30092; phone (404) 447-0335, fax (404) 448-0439. ■

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

FOUR outstanding graduate students have been announced as the 1994 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 1994 recipients were chosen from over 30 applicants who sought the Fellowships. The four are:

- Craig W. Bednarz, University of Arkansas, Fayetteville;
- Bryan G. Hopkins, Kansas State University, Manhattan;
- Grady L. Miller, Auburn University, Alabama;
- Stuart Pocknee, University of Georgia, Athens.

Funding for the Fellowships is provided through support by 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."

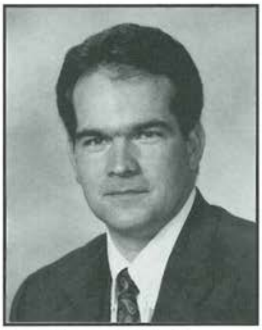
The Fellowship winners are selected by a committee of PPI scientists. The Fellowships are named in honor of Dr. J. Fielding Reed, retired President of the Institute, who now lives in Athens, GA.

Dr. W.R. Thompson, Jr., PPI Midsouth Director, served as chairman of the selection committee for the 1994 Fellowships.

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:

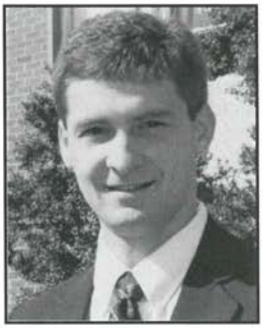

Craig W. Bednarz

Craig W. Bednarz was born in Slaton, TX. He received both his B.S. and his M.S. degrees at Texas Tech University. He is currently studying for his Ph.D. degree at the University of Arkansas. His doctoral research deals with the physiology of potassium (K) nutrition in cotton. His research in progress is designed to demonstrate how plant uptake of K can occur in apparent luxury amounts and how these resources can be re-translocated when needed. Mr. Bednarz would like to do postdoctoral work at a major university or other research establishment, which he believes will be beneficial in his finding a position in a university. His additional goal is to "contribute not only to the scientific community of which I am a member, but also to the local community in which my wife and I eventually reside."


Bryan G. Hopkins

Bryan G. Hopkins was born in Idaho Falls, ID. He attended Idaho State University, then Ricks College before receiving his B.S. degree from Brigham Young University (BYU). He also earned his M.S. degree at BYU and has been working toward his Ph.D. at Kansas State University since 1991. The objectives of his doctoral research are to conduct studies to determine grain sorghum response to zinc

(Zn), then correlate that response to soil Zn levels and possibly other soil parameters to formulate fertilizer guidelines. He will also evaluate sorghum hybrids to determine Zn use efficiency and critical nutrient ranges. Mr. Hopkins' long-term career goals include continuing research which refines soil fertility principles and practices. He would also like "to help bridge the gap between research and the real world by being an educator."



Grady L. Miller

Grady L. Miller is currently working toward a Ph.D. degree at Auburn University. He holds a B.S. degree from Louisiana Tech University and an M.S. degree from Louisiana State University. He is a native of Florien, LA. The title of his dissertation is 'Role of Potassium (K) Fertilization in Development of Freezing Resistance in Bermudagrass'. The objectives of his research are to (1) evaluate the residual effects of K on cold tolerance, (2) determine the influence of K on plant characteristics thought to be related to cold tolerance, and (3) identify the mechanism by which K influences freeze resistance in turfgrass. Mr. Miller would like to be a part of a multidisciplinary research team with the goal of increasing knowledge of turfgrass culture. He is also interested in teaching at both undergraduate and graduate levels.

Stuart Pocknee

Stuart Pocknee is a native of Brisbane, Australia. He earned a B.S. degree from the University of Queensland, in Australia. He is presently studying for his M.S. degree at the University of Georgia, under the direction of Professor Malcolm Sumner. Mr. Pocknee's research deals with the effects of organic matter additions on soil pH and the mechanisms of those effects. His interest in this type of study was generated by the fact that organic matter can be an effective alternative to lime where lime use is impractical, as in some developing countries. He characterizes early results from incubation studies as being 'very promising' with regards to pH response from different organic matter inputs. Mr. Pocknee would like to work as a soil fertility and soil conservation researcher in those areas of the world that are most threatened by degradation and production shortfalls. ■

Nutrient Management Conference Proceedings

PROCEEDINGS of a recent conference, "Nutrient Management on Highly Productive Soils," are available from PPI. The Conference took place May 16-18, 1994, in Atlanta, GA. It was organized by PPI and the Foundation for Agronomic Research (FAR), with co-sponsorship from government and industry sectors.

Conference discussion topics covered in the proceedings include: importance of maintaining soil fertility; fertilizer recommendations and spatial variability; site-specific nutrient management; individualized nutrient management recommendations; role of fertilizer placement in improved productivity; economic and environmental impacts of intensive cropping systems; a discussion of regulatory effects on fertilizer use, and numerous other topics.

The Proceedings (PPI/FAR Special Publication 1994-1, 187 pages) is available by mail at a price of $15.00. For more information or to order copies of the proceedings, contact: PPI, 2805 Claflin Road, Suite 200, Manhattan, KS 66502; phone (913)776-0273, (fax) 913-776-8347. ■

Are Present-Day Wheat Varieties More Sensitive to Phosphorus Deficiency?

By Paul E. Rasmussen

The title was to get your attention. The question is but one of many being asked in agricultural circles today. Can we answer it?

THERE ARE SEVERAL valid reasons why phosphorus (P) deficiency should be occurring more frequently in wheat fields today. They are:

1. Wheat yields are nearly double what they were 30 years ago, removing twice as much P per acre.
2. Newly-developed semidwarf wheats have less winter dormancy than their earlier counterparts. They begin growth earlier in the spring when soils are colder, which restricts root growth and decreases access to needed nutrients.
3. Newly-developed spring wheat varieties are less day-length sensitive. Again, this results in earlier growth in cooler soils.
4. New varieties tend to rely more on high tillering capability for high yield potential. Any early season nutrient stress will negatively impact tiller formation and has the potential to limit yield.
5. The increasing trend towards conservation tillage means wheat seedlings grow in a cooler environment. There is often greater pressure from soil-borne pathogens which prune the seedling root system. And rows are often wider for trash clearance, requiring better individual plant performance.

Is P deficiency occurring more frequently in modern wheat varieties? More importantly, are we conducting research to determine if it is? We can no longer merely apply fertilizer, take pictures, and determine grain yield. Too many things happen when the plant is growing. Did it tiller well? Was the root system damaged by plant pathogens? Was disease present? Did fertilizer application affect disease level? Did we utilize the correct rate of nitrogen (N), because N response often dominates all other nutrient responses? Were any other nutrients deficient? And what about dual placement of P and N? Was it so close to the seed that it caused plant damage? Was it close enough to the seed so that young seedlings had access to fertilizer? What was the water status throughout crop growth? Did drought stress occur at flowering?

The following figures illustrate some of the problems with defining nutrient needs of present-day varieties. **Figure 1** shows early growth response patterns in cereals. Cereals will not respond to nitrogen when sulfur (S) is deficient. And both N and S must be adequate for P response to occur. Phosphorus response in cereals generally appears only as greater growth and darker green color, without other visual deficiency symptoms. Correct identification of P deficiency requires proper analytical techniques.

Figure 2 illustrates the need to have optimum N fertility in order for P response to be expressed as increased grain yield. Phosphorus response did not occur until optimum rates of N and S were applied. It would have been easy to miss this response in an abbreviated soil fertility trial if the N rate was not correct . . . or if S had been omitted.

Back to the Important Question

During the past 25 years, there has been a steady decline in state and federal research dedicated to soil fertility. This

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Figure 1. Wheat response to N,S and P at tillering. **(Oregon)**

has not always been replaced by increased industry support. Most of the decline in numbers of researchers was from outlying locations where they concentrated on field research. Fewer researchers mean fewer field trials and more trials that are not always fertilized and seeded when they should be.

With fewer people in research, those remaining are concentrating on greenhouse and growth chamber experiments. But these types of studies will not tell us if P response is more prevalent now than in the past. That requires a wide array of multi-year field research trials encompassing the major soil types. And if we are changing tillage systems, we need 3 to 5 years in the new system before valid results are obtained. How do we evaluate yield level if P response is dependent on yield level? Do we throw out results obtained when drought stress limits yield? Drought is a normal part of many dryland wheat growing regions. Are the Bray and Olsen soil tests as reliable today as in the past? Or do they need recalibration?

Is the continuing loss of soil fertility research decreasing our ability to solve environmental problems? Is the shift towards greater percentage of support coming from industry resulting in more or less effective communication between researchers and farmers? At a time when means of communications are advancing by leaps and bounds, are we getting the answers to the problems to the right people?

If it is important to U.S. agriculture to solve problems such as this, do we need a new, cooperative, innovative federal/state/private industry effort? Who will be responsible for taking the lead?

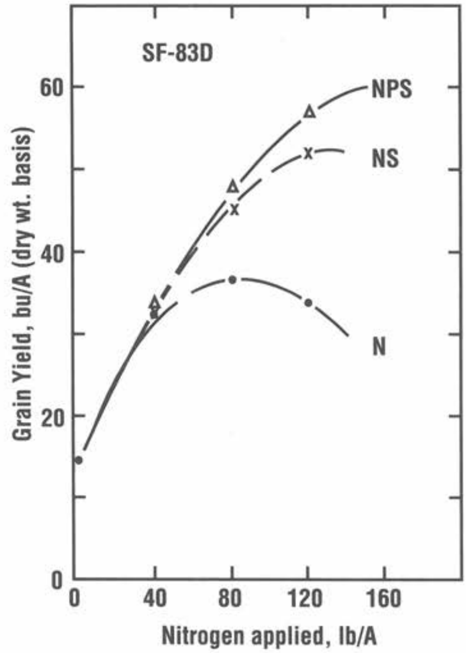

Figure 2. Wheat yield responses to N, N+S, and N+P+S emphasize the importance of meeting all nutrient needs. Adequate amounts of N (98 lb/A) and S (18 lb/A) were required for P response to occur. **(Oregon)**

Are present-day wheat varieties more sensitive to P deficiency? The answer is probably "yes", but we do not know for sure because the definitive research has not been done. A higher level of continued soil fertility research is essential to be able to provide updated information and recommendations for modern production systems. ■

Rotation and Nitrogen Fertilization Effects on Changes in Soil Carbon and Nitrogen

By G.E. Varvel

A long-term study comparing several different cropping systems showed soil carbon (C) levels were increased at rates up to 170 lb/A/yr in selected cropping systems at high nitrogen (N) fertilizer rates with conventional tillage.

LONG-TERM EFFECTS of management practices on soil properties provide information necessary to evaluate sustainability of cropping and tillage systems and their effects on the environment. Since soils can serve as both a source and a sink for atmospheric carbon dioxide (CO_2), soil and crop management can affect global balance of this greenhouse gas. Recent estimates indicate that for U.S. agriculture the current mix of tillage practices used in 1990 produced an emission rate of 8.8 million tons of CO_2 each year from soil organic C.

Reduced tillage, an obvious alternative, has been shown to reduce the rate of organic matter degradation. Research at several locations, especially in no-tillage systems, has shown increases in organic matter content as greater amounts of residue associated with increased yields are returned to the soil. Nitrogen fertilizer has also increased organic matter content, but mostly in monoculture systems.

Determination of long-term effects of cropping systems on soil properties, such as organic soil C and N levels, is necessary so accurate projections can be made regarding the sequestering and emission of CO_2 by agricultural soils. Our objective was to evaluate the effects of crop rotation and N fertilizer management on changes in total soil C and N concentrations that occurred during eight years in a long-term study in the western Corn Belt.

Long-Term Nebraska Study

A study, comprised of seven cropping systems (three monoculture, two 2-year, and two 4-year rotations) with three rates of N fertilizer, was conducted on a Sharpsburg silty clay loam near Mead, NE. Monocultures compared included continuous corn, continuous soybean, and continuous grain sorghum. The 2-year rotations in the study were corn-soybean and grain sorghum-soybean and the two 4-year rotations were corn-oat+clover-grain sorghum-soybean and corn-soybean-grain sorghum-oat+clover. Each phase of every rotation occurred every year. Nitrogen rates were 0, 80, or 160 lb/A for corn and grain sorghum and 0, 30, or 60 lb/A for soybean and oat+clover crops. Nitrogen was sidedressed as liquid urea-ammonium nitrate (UAN) solution (32-0-0) the first two years, and was broadcast as granular ammonium nitrate (34-0-0) in succeeding years. Oat+clover plots received broadcast N in May. Nitrogen was applied in early- to mid-June for corn, grain sorghum, and soybean.

Cultural practices were similar to those used by local producers. Previous crop residue from corn or grain sorghum was shredded in late fall with a rotary mower. Clover from the previous oat+clover plots was killed with a tandem disk in mid-April when weather permitted. Spring tillage usually consisted of disking once or twice 4 to 6 inches deep and then harrowing just prior to planting.

Soil samples were taken each spring prior to planting to evaluate the effects of rotations, crops, and N rates at depth

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increments of 0 to 3, 3 to 6, and 6 to 12 inches.

Results

Soil samples at the beginning of the study indicated no differences in total C or N concentrations between cropping system at any depth. Total C concentrations for the entire study in 1984 averaged 1.69 percent at the 0 to 3 inch, 1.47 percent at the 3 to 6 inch, and 1.20 percent at the 6 to 12 inch depths. Similarly, total N concentrations averaged 0.16 percent at the 0 to 3 inch, 0.14 percent at the 3 to 6 inch, and 0.12 percent at the 6 to 12 inch depths.

After eight years, rotations and N rates affected total soil C and N concentrations in the surface 0 to 3 inch depth. Total soil C and N concentrations (0 to 3 inch depth) for 1992 averaged 1.72 and 0.16 percent for continuous corn, 1.66 and 0.17 percent for continuous soybean, 1.76 and 0.17 percent for continuous grain sorghum, 1.63 and 0.16 percent in two-year rotations and 1.77 and 0.16 percent in four-year rotations, respectively.

Nitrogen fertilizer rate also affected total soil C and N concentrations during the first eight years. Total soil C concentrations (0 to 3 inch depth) for 1992 averaged 1.69, 1.73, and 1.77 percent and soil N concentrations averaged 0.16, 0.17, and 0.17 percent for 0, low, and high fertilizer N rates, respectively.

The cumulative amount of C and N sequestered or lost over the eight-year period in each of the cropping systems for the 0 to 6 inch depth is shown in **Table 1**. In actuality, most of the significant differences in total soil C and N concentrations occurred in the 0 to 3 inch depth, but because tillage is occurring on an annual basis to a greater depth than that, the total amount of C and N sequestered or lost to a depth of 6 inches is presented.

Table 1. Effects of crop rotations and N fertilization on total soil C and N sequestered in an 8-year period.

Rotation[1]	N fertilizer rate 0	Low	High
	---- C sequestered, lb/A (0-6 inches) -----		
CC	-477	166	1213
CSB	-764	-181	-324
CSG	231	1175	1374
C-SB	-252	-166	-62
SG-SB	298	203	796
C-OCL-SG-SB	777	575	1268
C-SB-SG-OCL	405	904	1126
	---- N sequestered, lb/A (0-6 inches) ----		
CC	13	99	169
CSB	-50	-4	-13
CSG	-17	76	104
C-SB	15	49	51
SG-SB	66	63	111
C-OCL-SG-SB	102	101	158
C-SB-SG-OCL	10	59	88

[1] CC = Continuous corn, CSB = Continuous soybean, CSG = Continuous grain sorghum, C-SB = Corn-soybean, SG-SB = Grain sorghum-soybean, C-OCL-SG-SB = Corn-oat+clover-grain sorghum-soybean, C-SB-SG-OCL = Corn-soybean-grain sorghum-oat+clover.

Summary

The results from this study indicate that selection of cropping system and the level of N fertilization can greatly affect CO_2 emissions and sequestration, even to a much greater extent than recently proposed. A study from the Council for Agricultural Science and Technology (CAST Report 119, 1992) calculated that soil C levels would be increased 890 to 2,670 lb/A in the next 40 years if high yielding varieties, N and phosphorus (P) fertilizers, no straw removal, and minimum tillage practices were adapted autonomously. In this study, soil C levels were increased at rates up to 170 lb/A/yr in selected cropping systems at high N fertilizer rates with conventional tillage systems. It appears that it is not only the amount of crop residue being returned to the soil that is important, but the amount and type of crop residue. Greater storage of C in soils with these practices suggests CO_2 emissions from agricultural soils could be decreased and may in the long term have a significant effect on CO_2 in the atmosphere under current climate conditions. ■

Georgia

Late-Season Fertilization of Soybeans with Nitrogen and Boron

By Gary J. Gascho

Most fertilization for soybeans is prior to planting. Basic research has shown that modern soybean cultivars require much of their nutrition late in the season, in reproductive stages, for optimum seed set and development. Sandy soils in the Southern Coastal Plain do not retain nutrients well. Therefore, fertilization prior to planting may not result in optimum nutrition throughout the reproductive cycle. Research indicates increased yield due to late-season foliar applications and fertigation with nitrogen (N) and boron (B)

NITROGEN needs of the soybean plant during pod-fill are great. Nitrogen availability to the developing seed comes via the vegetative plant from symbiotically fixed N, residual soil N or fertilizer N. The majority of the mineral N in soils exists as nitrates under good growing conditions. Southern Coastal Plain soils retain only small amounts of residual nitrate-N against leaching due to their porosity and lack of anion exchange capacity. Also, little or no fertilizer N is applied. Therefore the primary N source must be N fixation. Modern cultivars have high yield potentials which require N nutrition throughout pod-fill, and N fixation may not be adequate to supply all of the N. If the N supply is not adequate during pod-fill, there may be several consequences:

- Seed number and seed size will be reduced, possibly due to early senescence;
- Yield potential of the cultivar will not be achieved;
- Protein content of the seed may be reduced.

Recently, the value of B applications to soybeans following vegetative growth has been shown in several studies. Boron injected directly into soybean plants increased pod numbers on lateral branches and increased yield in studies conducted in Missouri. Follow up studies indicate that similar responses are often obtainable with foliar B applications. The physiological cause(s) of responses to B applications are not clear, but several mechanisms are under consideration:

- Boron increases the plasticity of cell walls of flower parts, thus decreasing pod abortion;
- Boron changes membrane activity which affects ion transport for essential nutrients such as potassium (K), calcium (Ca) and magnesium (Mg);
- Boron improves translocation of sugars in the plant, possibly as sucrose-borate complexes;
- Greater B concentrations in flowers increase pollen germination.

Georgia Coastal Plain Studies

Late-season N applications to soybeans have been studied at the Coastal Plain Experiment Station, University of Georgia, since 1988. Earlier research clearly indicated that no yield or gross physiological responses were obtained from N applications before flowering. Field studies were conducted with fertigation (0.1 to 0.2 in. water/A) from 1988 to 1991 and with foliar sprays from 1988 to present. Boron and N + B combinations have been applied since 1990. Responses were

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recorded for the fertigation application method. However, since few farmers have the necessary equipment to fertigate soybeans, emphasis has now been placed on foliar sprays.

Application technology for foliar sprays has evolved during the studies, increasing the consistency of responses by that method. Presently, 10 to 20 lb N/A is applied as low-biuret, feed-grade urea and 0.25 to 0.4 lb B/A is applied as a soluble sodium borate. Water volume has been 20 to 25 gal/A. Sprays are made late in the day in order to minimize rapid drying on the leaf surface, maximize absorption time and minimize leaf burns. Field observations indicated that inclusion of B with N eliminated a slight leaf burn associated with applications of N alone.

Table 1 shows that yield responses were recorded for foliar applications of N, B and N + B during pod development (R4) on both a sand and a sandy loam in 1992. The Bonifay soil has much less nutrient and water retention than the Greenville soil. Responses on the Bonifay were greater than on the Greenville, a result consistent with the lesser ability of the sand to retain N and B. Yield responses greater than 5 bu/A have often been recorded on sands and loamy sands, while responses on loamy soils have generally been less than 2 bu/A. Greatest response in 1992 was to foliar sprays of N + B at the sand site. Modest seed protein responses are also noted, a result consistent with other years in which late-season N was applied.

Table 1. Soybean yield and protein concentration in seed from spray treatments made during pod development (R4) at two sites in 1992[1].

Nutrients applied	Yield, bu/A		Protein, %	
	Bonifay[2]	Greenville[3]	Bonifay	Greenville
None	37.8	38.3	31	36
N	44.3	40.7	–	–
B	38.9	43.6	–	–
N + B	46.0	42.2	34	37

[1]Means for 5 cultivars. [2]Bonifay is a sand. [3]Greenville is a sandy loam.

Separate studies with only B applied foliarly were also conducted in 1992 at the Bonifay and Greenville soil sites, **Table 2**. Initial sprays were applied at first bloom at 0.25 lb B/A for the 0.25, 0.50 and the 1 lb/A rates. A second application at the same rate was applied to the 0.5 and 1 lb treatments 2 weeks later and two additional applications to the 1 lb treatment were made at 2-week intervals. Yield responses of 2 to 9 bu/A were attained on the sand site. No yield response was found on the sandy loam. Lateral branching and seed weight were increased by B applications.

Summary

Research has indicated a fairly wide time-window of opportunity for fertigated and foliar N and B application during reproductive development. Most of the soybeans grown in the Southeast must be sprayed at least once during this period for either diseases or insect pests. And because application is a major cost of N and B foliar feeding, continued research is planned to combine N, B and N + B with pesticides. Pesticide-nutrient mixtures will be sprayed at the timing needed for the pesticide. Such combinations, if effective, may reduce costs for nutrient applications to only the material costs for fertilizer materials. ■

Table 2. Soybean yield, lateral branching and seed weight on two soils as affected by foliar B application, 1992.[1]

B rate, lb/A	Yield, bu/A		Branches, no./plant		Seed weight, g/100 seed	
	Greenville	Bonifay	Greenville	Bonifay	Greenville	Bonifay
0	55	48	9.0	5.4	18.1	16.2
0.25	56	54	9.3	6.1	19.1	17.7
0.50	56	50	9.8	6.9	18.5	17.1
1.00	55	57	9.4	6.8	18.8	17.3

[1]Means for 5 cultivars.

Suppression of Physiological Leaf Spot in Winter Wheat by Chloride Fertilization

By Richard Engel and Paul Fixen

Physiological leaf spot in Redwin winter wheat and other susceptible varieties was found at low soil chloride (Cl) sites and was greatly suppressed by Cl fertilization.

GREAT PLAINS SOIL RESEARCH has shown that foliar diseases in wheat are sometimes suppressed by Cl fertilization. The list includes leaf rust, tanspot, and Septoria leaf blotch. Recently, Montana studies indicate a "physiologic" leaf spot that appears in certain winter wheat varieties is greatly suppressed by Cl fertilization.

The term "physiologic" is used to describe leaf spots of unknown origin. Lesions typically appear at flag leaf emergence. Symptoms are first apparent on the lower or oldest leaves and progress to successively younger leaves over a 2 to 3 week period. Symptoms are often more severe towards the distal or tip half of the leaf blade. In severely affected plants, lesions coalesce, resulting in premature leaf senescence during the grain-ripening period. Symptoms are described as being similar to tanspot and Septoria leaf blotch diseases, but plant pathogens responsible for these diseases, i.e. *Septoria nodorum* and *Pyrenophora tritici f.* sp. *repentis*, cannot be isolated from affected tissue. Physiologic leaf spot occurrence and severity are dependent on variety selection and plant environment. Specific winter wheat varieties exhibit leaf spot symptoms while other varieties grown at the identical location do not. Also, among susceptible varieties there is great variability in symptoms from one season and locale to the next.

Susceptible Varieties

Research over a three-year period (1991-1993) revealed three winter wheat varieties (Redwin, Manning, Kestrel) for which leaf spot severity was reduced by Cl fertilization. Other varieties susceptible to physiologic leaf spot and responsive to Cl fertilization probably exist, but have not been demonstrated in research trials. In Montana, Redwin winter wheat is probably the variety most commonly associated with this physiologic leaf spot phenomenon. The first experience with Cl suppression of physiological leaf spot occurred in 1991 at a site near Garryowen, MT, with only 4 lb/A soil Cl (0-24 in. depth). Chloride application as potassium chloride (KCl) had a dramatic and visually obvious effect on leaf spot severity in Redwin and Manning winter wheat. The Cl component in this fertilizer was responsible for the leaf spot suppression since potassium sulfate (K_2SO_4) had been

CHLORIDE APPLICATION and variety affect physiological leaf spotting in winter wheat. Redwin variety is shown here. The plot at left received Cl application; the plot at right shows symptoms on leaves without Cl application.

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Table 1. Physiological leaf spot severity in flag leaves of several winter wheat varieties as affected by Cl and propiconazole (Tilt).

	Leaf spot, %			
	Control		Propiconazole (Tilt)	
Cultivar	-Cl	+Cl	-Cl	+Cl
Kestrel	23.7	3.7	26.5	2.3
Redwin	7.0	0.3	5.2	0.1
Tiber	0.2	0.1	0.0	0.0

South of Lodgegrass, MT (Bighorn Mtn. Foothills) 1993

applied to the control areas. Initially, these results came as a great surprise.

Because symptoms were similar to tanspot and since Cl had been shown to suppress this disease in South Dakota, we initially believed the response was an example of foliar disease suppression. However, results from more recent investigations now suggest the leaf spot phenomenon is probably not disease related, but a physiological disorder. There are three reasons for this conclusion: 1) application of propiconazole (Tilt) has no effect on leaf spot severity, 2) a causal organism cannot be isolated from affected areas of leaf blades, and 3) Tiber, a Redwin variety selection with leaf spot tolerance, does not exhibit lesion symptoms. See **Table 1**.

Effect of Available Cl on Leaf Spot Severity

Relationship of physiological leaf spot severity and available Cl at a site south of Lodgegrass, MT (Bighorn Mountain foothills) indicated only small amounts of fertilizer Cl are required to dramatically reduce leaf spot severity. **Figure 1** shows that coincident with a reduction in leaf spot severity is a near linear increase in whole plant Cl concentration. Physiologic leaf spot in Redwin disappears at whole plant Cl concentrations greater than 0.30 percent. The results from this site and five other locations (data not shown) suggest that if physiological leaf spots occur in Redwin winter wheat, there is a high probability the Cl concentration in the plant and/or soil is extremely low.

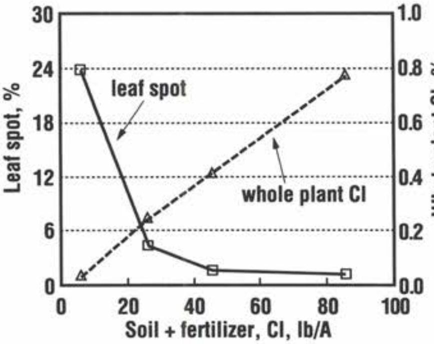

Figure 1. Physiological leaf spot severity and whole plant Cl in Redwin winter wheat as affected by available Cl in soil 0-48 in. plus fertilizer Cl.
South of Lodgegrass, MT. 1993

Low soil or plant Cl status is not a guarantee that physiologic leaf spot will occur in susceptible varieties. We have observed very little spotting even though soil and plant Cl levels were very low (less than 10 lb/A in 0-24 in. depth; less than 0.10 per-

EFFECTS of Cl are shown in these photos of Kestrel variety winter wheat. Plot at left received Cl application; plot at right shows leaf spotting symptoms without Cl.

Table 2. Chloride fertilizer increased grain yield and mature kernel weight in leaf spot susceptible winter wheat varieties.

Site	Variety	Yield, bu/A		Mature kernel wt., g/1,000 kernels	
		-Cl[1]	+Cl[2]	-Cl	+Cl
1	Redwin	47.0	49.5	28.6	31.7
	Manning	49.5	51.6	31.5	34.0
2	Redwin	82.0	94.2	33.7	36.7
	Manning	77.9	83.8	31.7	34.1
3	Redwin	56.9	62.8	33.5	36.6
	Manning	69.8	76.4	35.7	38.8
4	Kestrel	64.5	70.5	30.5	31.3
	Tiber[3]	64.8	66.8	33.0	34.3
	Redwin	71.1	78.8	32.4	33.8
	Manning	53.7	60.3	28.6	30.3
5	Redwin	60.3	65.7	34.0	35.8
Mean		63.4	69.1	32.1	34.3

Site 1 = Garryowen (1991), 2 = Bighorn Mtn. foothills (1992), 3 = Lodgegrass (1992), 4 = Bighorn Mtn. foothills (1993), 5 = Bighorn Mtn. foothills (1993).

[1]Without applied Cl fertilizer.

[2]40 lb Cl/A at sites 1-3, 60 lb Cl/A at site 4, and mean of 20, 40, and 80 lb Cl/A at site 5, respectively.

[3]Tiber is a Redwin selection, not susceptible to leaf spotting.

cent Cl in whole plant). Other factors appear to play a role in the severity and development of these lesions. To date, our experience indicates that in susceptible varieties, leaf spotting is favored by a combination of low soil Cl, plus prolonged wet and cool weather.

Grain Yield and Kernel Weight Response to Cl Fertilizer

Chloride fertilization has consistently increased winter wheat grain yield and mature kernel weights at sites with physiological leaf spot, detailed by data in **Table 2**. Yield responses to applied Cl averaged 5.7 bu/A or 9.0 percent, but varied considerably with location. Thousand kernel weight increases from applied Cl averaged 6.9 percent, hence kernel size was probably the most important yield component affected by Cl. Leaf spot suppression by Cl may explain a portion of the yield responses. A reduction in photosynthetic area due to lesion formation, particularly in the flag leaves, could affect yield by reducing kernel size at harvest. Tiber, a Redwin selection not affected by the leaf spotting phenomenon, exhibited a slightly smaller response to Cl at Site 4.

Although Cl rate comparisons have not been included at all locations, research on winter wheat in Montana generally suggests that 30 lb/A of available Cl, fertilizer plus soil (0-24 in. depth) Cl, are required for maximum production. The most common Cl fertilizer is 0-0-60 (KCl). At a price of approximately $145/ton, the nutrient would represent a cost of $0.15/lb Cl. Therefore, the material cost of applying 20-30 lb Cl/A is only $3.00-4.50 if the value of K in the fertilizer is ignored. A grower using this Cl application rate would suppress leaf spotting in susceptible varieties, and realize over a $4.00 return per dollar spent on Cl fertilizer in the first year. In addition, a large percentage of applied fertilizer Cl may be available to succeeding wheat crops under dryland conditions. Only small amounts of Cl absorbed by the wheat plant are translocated to the grain (less than 3 lb/A). Most Cl remains in the straw and is released to the soil as the residue decomposes. As rainfall is comparatively low in much of the wheat belt, leaching events are infrequent even though Cl is mobile in soils.

Summary

In Montana, a leaf spot of non-pathogenic origin is frequently observed in selected winter wheat varieties. Lesion occurrence appears to be due to genetic background or physiological processes in affected varieties, rather than due to microbial infection. Leaf spot severity is closely associated with soil or plant Cl nutrition. Where leaf spots occur there is a high probability that both soil and plant are low in Cl. Other environmental factors such as high moisture and cool temperatures may contribute to the leaf spot problem. Small and comparatively inexpensive fertilizer Cl applications, perhaps $3.00 to $4.50/A can greatly suppress physiological leaf spot and result in increased yield and profits to the grower. Chloride yield responses can also occur when no leaf spotting is present. ■

Wheat Management Publications Available from Canada Grains Council

THE CANADA GRAINS COUNCIL has taken the lead in development of four publications which will be useful to individuals interested in intensified wheat production. These publications include the Risk Management Guide for Wheat Production, a Field Scouting Guide, a Wheat Production Reference Manual, and an Intensive Wheat Management Production Guide.

The Risk Management Guide was developed as an information source to assist farmers in making crop management decisions.

The Field Scouting Guide was prepared to help farmers, Extension workers, crop consultants and fertilizer dealers in scouting fields for pests and recording the base data at appropriate times.

The Wheat Production Reference Manual can help growers become better equipped for production of wheat at optimal yield levels for achieving maximum economic returns.

The Intensive Wheat Management Production Guide has been developed around three keys to farm business operations: Know your market, know your costs, and know your product.

Copies of the publications can be ordered from the Canada Grains Council, 760-360 Main Street, Winnipeg, MB R3C 3Z3. Price for the full set of these publications is $35 Canadian plus $8 postage and handling. The Risk Management Guide and the Field Scouting Guide are available at $10 Canadian (each) plus $4 postage and handling. The Intensive Wheat Management Guide price is $5 Canadian per copy plus $4 postage and handling. ■

Alabama

In-Row Subsoiling and Potassium Placement Effects on Root Growth and Potassium Content in Cotton

A TWO-YEAR FIELD STUDY was conducted to evaluate cotton root development and dry matter yield as affected by in-row subsoiling and potassium (K) fertilizer placement. The experiment was located in central Alabama, on a sandy loam soil.

Five treatments were compared: (1) check, no subsoiling, (2) check, with subsoiling, (3) 90 lb K_2O/A, surface-applied, no subsoiling, (4) 90 lb K_2O/A, with subsoiling and (5) 90 lb K_2O/A deep-placed in the row. The soil was shown to have a well-developed traffic pan at a depth of approximately 6 to 15 inches.

In-row subsoiling disrupted the traffic pan up to 10 inches from the in-row position. Root density measurements taken in-row showed that root growth at depths greater than 8 inches was improved by sub-soiling and K fertilization, with growth generally better where K was deep applied. However, broadcast K in combination with sub-soiling resulted in highest productivity and K accumulation per plant.

Researchers suggest that, based on this study, deep placement of K is not superior to broadcast applications for cotton production in Alabama. ■

Source: Mullins, G.L., D.W. Reeves, C.H. Burmester and H.H. Bryant. 1994. Agron. J. 86:136-139.

Indifference Is Worse Than Ignorance

THERE IS NO EXCUSE FOR IGNORANCE ABOUT THE WORLD FOOD CRISIS. Population growth continues. The numbers are widely publicized...5.6 billion people today—4.4 billion live in so-called developing countries. Many of these people don't receive adequate nutrition now.

WHAT WILL IT BE WHEN THE POPULATION IS BILLIONS MORE?

A FEW MAY PLEAD IGNORANCE OF THESE MATTERS...BUT TOO MANY ARE GUILTY OF INDIFFERENCE. Our generation will not be excused for failing to prepare for the future. Feeding tomorrow's world will demand the best efforts of:

1. *Agricultural scientists*
2. *Educators*
3. *Environmentalists*

TO MEET THE POPULATION CRISIS CALLS FOR CLOSE COOPERATION AMONG THESE GROUPS. Indifference of one group to the importance of the other will mean failure.

As agricultural research develops food production practices that are more efficient and resource conserving, the best educational efforts will be needed to teach these to all nations. The environmentalists must keep up with world needs and scientific evidence and base their programs on facts rather than emotions. *Improved production, education and conservation—all three.*

When indifference plunges us into darkness, the roar of machine guns begins.

J. Fielding Reed

BETTER CROPS WITH PLANT FOOD
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