BETTER CROPS
WITH PLANT FOOD

1995 Number 4

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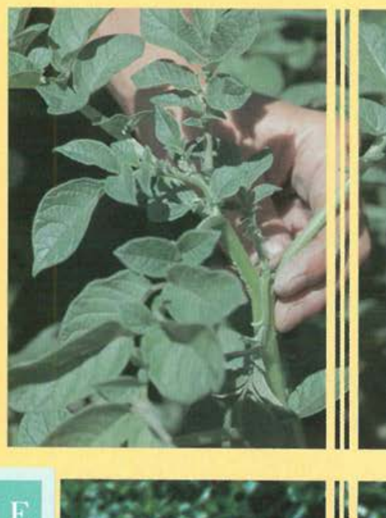

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BETTER CROPS
WITH PLANT FOOD

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Our Cover: Potato field, plants and bloom.
Photos: Dr. T.A. Tindall
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CONTENTS

John U. Huber Elected Chairman, Charles O. Dunn Vice Chairman of PPI and FAR Boards of Directors

John U. Huber, Executive Vice President of The Vigoro Corporation and President, KCL Holdings, Inc., Kalium Chemicals, Ltd., and Phoenix Chemical Company, was elected Chairman of the PPI Board of Directors at a recent meeting. He will also serve as Chairman of the Foundation for Agronomic Research (FAR). Charles O. (Chuck) Dunn, President and CEO, Mississippi Chemical Corporation (MCC) is the new Vice Chairman of the PPI and FAR Boards.

John U. Huber

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

Throughout the 1960s and 1970s, Mr. Huber held various supervisory positions at Kalium. He was named plant manager of the company's main potash facility in Belle Plain, SK, in 1975, and during the next 15 years held positions of increasing responsibility, including General Manager, Canadian Operations, and Vice President of Sales.

Charles O. Dunn

A native of Saskatchewan, Mr. Huber earned a bachelor's degree in chemical engineering from the University of Saskatchewan in 1960.

Mr. Dunn was elected President and CEO of MCC in 1993. Born in Bolivar County, MS, he received his B.A. degree in 1970 from The Citadel in Charleston, SC. After serving as an officer with the U.S. Army, he attended the University of Alabama School of Law, graduating in 1975. He practiced in Atlanta, GA, specializing in corporate and tax law. He joined MCC in 1978, as an attorney in the legal department at company headquarters in Yazoo City, MS.

In other action of the PPI Board, Mr. John M. Van Brunt, President and CEO, Agrium Inc., was elected Chairman of the Finance Committee. New members of the PPI Board of Directors include Mr. Mark G. Boulanger, Western Ag-Minerals Company, and Mr. John Lewandowski, New Mexico Potash.

New members of the FAR Board of Directors include Mr. Gary L. Roth of Western Ag-Minerals Company, Dr. R.E. Stuckey of the Council for Agricultural Science and Technology, Dr. R.A. Wiese of the Fluid Fertilizer Foundation, and Dr. W.R. Thompson, consultant, PPI (retired). BC

Robert E. Wagner Award Recipients Announced

Two outstanding agronomic scientists have been selected to receive the 1995 Robert E. Wagner Award by PPI. The Award allows for 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.

Dr. Loraine D. Bailey of Agriculture and Agri-Food Canada's Brandon Research Centre was selected in the senior scientist category. Mr. David Qiupeng Zeng, Soil and Fertilizer Institute of the Guangdong Academy of Agricultural Sciences, People's Republic of China, received the honor in the young scientist division.

Dr. L.D. Bailey

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, retired President of PPI, for his many achievements and in recognition of his development of the MEY management concept...for more profitable, efficient agriculture.

"To honor Dr. Wagner through the selection of Dr. Bailey and Mr. Zeng truly exemplifies the purpose of this award," said Dr. David W. Dibb, President of PPI. "With nominations received from all over the world, these two individuals represent the high standards of the Robert E. Wagner Award."

Dr. Bailey is located at Brandon, MB, Canada. Through his research on fertilizer use efficiency, he has contributed significantly to improved fertilizer management practices for various crops. His research on phosphorus, potassium, sulfur, growth stage, and time of harvest for alfalfa showed that growers could greatly increase yield and quality. He has acted as an advisor on graduate student committees and has been involved with the training of scientists through the Canadian International Development Agency and World University Service Canada. Dr. Bailey is a leader in agronomic research in Canada and an accomplished writer and speaker.

Mr. Zeng is presently working on mineral nutrition of fruit crops as a visiting scholar at the University of California-Davis. He is dedicated to research with fertilizer use for maximizing agricultural production. In collaboration with local scientists, Mr. Zeng has conducted greenhouse and field research on soil fertility and plant nutrition. As a result, more farmers are adopting higher fertilizer application rates where MYR demonstrated MEY could be obtained by combining higher plant populations, tissue culture planting and high N and K application rates with stable P fertilization. Mr. Zeng is steadfast in promoting the concepts of balanced fertilization to local agronomists and farmers in south China. BC

David Zeng

Information Agriculture Conference

PLANNED FOR JULY 30 - AUGUST 1, 1996

Dates for the 1996 Information Agriculture Conference are now set for Tuesday, July 30 through Thursday, August 1. The event will take place at the Krannert Center for the Performing Arts, University of Illinois, Urbana. Plans were announced by Dr. David W. Dibb, President of PPI.

Dr. Harold F. Reetz, Jr., PPI Midwest Director, Monticello, IL, will serve as chairman of the coordinating committee for the conference. Sponsors will include PPI, the Foundation for Agronomic Research (FAR), National Center for Supercomputer Applications (NCSA), University of Illinois College of Agricultural, Consumer and Environmental Sciences and others to be announced.

The conference will focus on site-specific crop and soil management technology and computer communication systems for agriculture. Program features will include yield mapping and interpretation, variable rate systems, data management, remote sensing, global positioning system potential, geographic information systems, and communication developments.

A larger exhibit hall will allow even more space for companies and organizations to display products and services related to modern crop production and information. An area will also be available for volunteer "poster" presentations where researchers and others can share results of studies and field experience.

Registration fees are $200 per individual before July 15, 1996 (students $100). Exhibitor fee is $300 for a 10 x 10 foot booth, which also includes conference registration for one person.

THE CYBERFARM *demonstration area will feature more on electronic information and record systems at the 1996 Information Agriculture Conference.*

For registration and lodging information, contact:

Mary Hughes, PPI
2805 Claflin Road, Suite 200
Manhattan, KS 66502
Phone (913) 776-0273
Fax (913) 776-8347
E-mail: 72253.114 @ compuserve.com

For more information on exhibit arrangements, contact:

Bill Agerton, PPI
655 Engineering Drive, Suite 110
Norcross, GA 30092-2843
Phone (770) 447-0335, ext 209
Direct line: (770) 825-8074
Fax (770) 448-0439
E-mail: 73074.3713 @ compuserve.com

Potential co-sponsors and those interested in supporting the conference may contact Dr. Larry S. Murphy at the PPI Manhattan, KS, office: (913) 776-0273 BC

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

T E X A S

Research Tracks Potassium Dissipation Patterns in Rice Production

By Garry N. McCauley

Water quality and the potential impact of agricultural practices on water quality are among the most compelling environmental issues facing our society. People are concerned about the water they drink, its safety and what is being done to protect its quality. Unfortunately, what they read, hear and see is often confusing…and not always based on good science.

Most Texas rice production is concentrated in areas near the Gulf Coast. Flood waters leaving rice fields can impact on surrounding areas, including coastal waters. This study was established to evaluate the environmental impact of nitrogen (N), phosphorus (P) and potassium (K) fertilization of rice grown under flood management. An earlier article (BC, Vol. 79, No. 3, 1995) dealt with P fertilization. This one discusses K.

Earlier small plot research conducted by Texas A&M University scientists showed that with proper pesticide and water management there is little potential for non-point source runoff from rice fields. However, those studies are more than 20 years old and did not include P and K fertilization as variables.

This study was designed to define the degradation patterns and estimate non-point source runoff of P and K.

Twenty producers in a four-county area (Colorado, Jackson, Matagorda and Wharton) were recruited by county Extension agents to participate in the study. Producers took a water sample at the inlet and outlet of each test field following each rain and flush irrigation. Following flood establishment, inlet and outlet samples were taken when the flood reached the bottom of the field and at three day intervals until four samples were taken or at least 12 days after establishment. It was assumed that K (and P) would be dissipated from flood water within 12 days after the flood had reached the bottom of the field.

The 20 producers took a total of 220 samples at 116 different times. There were 104 matched inlet and outlet samples, with 12 outlet samples being taken when no inlet water was available.

Little is known about the levels and impact of K on the environment. It has not been considered to be of any potential damage to the environment or to human health as a result of crop fertilization. Potassium concentrations in all samples taken by farmers participating in this project were rather low. No samples tested contained more than 8.0 parts per million (ppm) K. The only one testing that high was an inlet sample. Sixty percent were non-detectable (less than 0.1 ppm).

Samples were divided into seven groups to allow for detailed interpretation (**Table 1**). Groups A through E can only be interpreted to have a neutral or positive environmental impact. Group F could possibly be a negative environmental factor, the magnitude depending on the amount of concentration increase and whether any such effect of K had been established. The

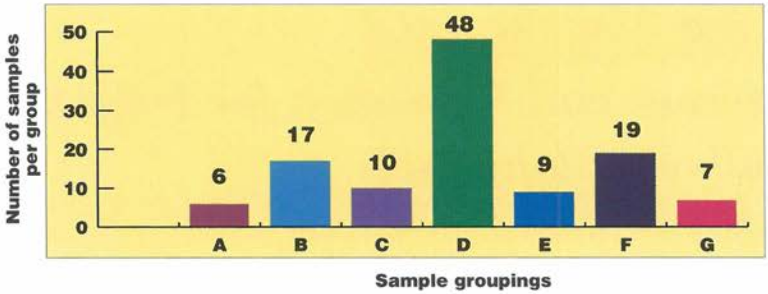


FIGURE 1. *Distribution of inlet-outlet sample change in K concentration for 116 rice field water samples.*

impact of G group can not be determined because there was only one sample taken, but it is assumed to be negative (conservative interpretation).

Figure 1 characterizes the sample distribution for K. Ninety of the samples, 78 percent of the total, were in groups A through E (no environmental impact). Nineteen of the samples increased in concentration, while seven outlet samples...with no matching inlet sample...had detectable concentrations.

Figure 2 presents the distribution by sample increase. Of the 26 that increased in K concentration, 15 increased by only 1.0 ppm, another six by 2.0 ppm. Of the five samples that appeared to increase by more than 2.0 ppm, two were outlet samples with no inlet partner with which to make comparisons. All were samples from the first water to be applied to a field after a preplant K application. Two of the five samples were from fields that received no K fertilizer.

TABLE 1. *Seven water sample groups used to determine potential effects of K fertilization.*

A = No inlet—outlet non-detectable
B = Concentration declined to non-detectable
C = Concentration declined, still detectable
D = Inlet and outlet samples non-detectable
E = Detectable levels—no change
F = Concentration increased
G = No inlet sample—detectable level in outlet

In summary, K in rice field runoff was less than 9 lb/A per season and presented little or no environmental threat. Further, there was no correlation between K in runoff and fertilizer K. In fact, some of the fields which received no K fertilizer had some of the highest seasonal losses. BC

Dr. McCauley is Associate Professor, Texas A&M University System, Eagle Lake, TX.

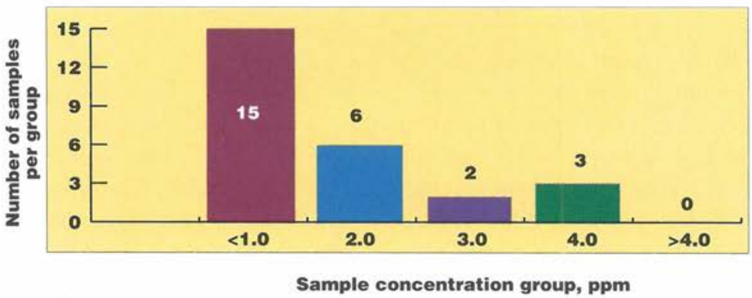


FIGURE 2. *Distribution of K concentration increase from inlet to outlet for 26 rice field water samples that increased.*

Potatoes and Potassium for Irrigated Southern Idaho Soils

By Terry A. Tindall and Dale T. Westermann

Potatoes, a culinary mainstay for many Americans, are at the heart of Idaho agriculture. Historical soil test information in southern Idaho is showing a general decline in available K concentrations from >400 parts per million (ppm) in the 1960s to 100 to 200 ppm today, suggesting growers are under-fertilizing for present production levels. Potatoes utilize and remove several hundred pounds of K/A at desired yield levels. Information on K fertilizer management needs to be re-evaluated to increase use efficiency and maximize potential benefits.

The University of Idaho presently sets the K soil test critical value for potato production at about 150 ppm ($NaHCO_3$ extraction). Relatively high potato yields (over 500 cwt/A) are being achieved by many of Idaho's potato growers. At this production level, the equivalent of over 250 lb/A of K_2O can be removed in the tubers. These tremendous requirements of K necessitate a relatively abundant supply of available K to the growing plant throughout the growing season.

Idaho growers typically monitor K and other nutrients weekly through petiole analysis. Many fields fall below suggested K petiole critical ranges during mid- and late-season tuber growth. To alleviate the concerns of potential K deficiency, growers are applying in-season K by solution injection in irrigation water (fertigation).

A 4-year study of potassium (K) requirements of potatoes in southern Idaho indicates that current soil test critical levels suggested by the University of Idaho are appropriate, but that the rate of fertilizer K within each category should be increased. Potassium fertilization can benefit both total yield and the percent of large tubers (>10 oz). Potassium sulfate (K_2SO_4) produced tubers with higher specific gravity. There appeared to be no advantage from splitting K applications compared to all K preplant unless the rate was high and salt damage became a possibility.

Very little information is available to direct these in-season applications or to indicate how late during tuber growth K can be applied without detrimentally affecting tuber quality. A study was initiated to determine (a) K fertilizer requirements for Russet Burbank potatoes, (b) effectiveness of K solutions applied during tuber growth, (c) the relative effectiveness of K sources, and (d) the K dynamics in the potato plant as related to petiole K concentrations. This article focuses on tuber yield and quality responses obtained with K fertilizer applications.

Idaho Studies

A series of experiments on growers' irrigated fields has been conducted over a four-year period. All experiments evaluated K fertilizer application rates, sources, broadcast versus banding and preseason versus split applications. Sources included potassium chloride (KCl) and K_2SO_4. Potassium fertigation was simulated by

TABLE 1. *Overall effect of K on tuber yields and specific gravity.*

Yield parameter	1992 -K	1992 +K	1993 -K	1993 +K	1994 -K	1994 +K
Total, cwt	416	440	330	357	408	419
US #1, cwt	254	254	124	134	296	302
Large US #1, cwt[a]	73	106 *	–	–	82	103 *
>10 oz, %	17.5	26.9 *	–	–	29	33 *
Specific gravity	1.083	1.082	1.088	1.088	1.082	1.080
Available soil K[b]	102		85		131	

*** Significant difference, $P \leq 0.05$.**
[a] Large US #1 refers to US #1 potatoes over 10 oz.
[b] Sodium bicarbonate extraction, 0-12 inch samples.

application of K during sprinkler events.

The K status of each treatment was monitored by sampling the fourth mature petiole from the growing point as well as vines, roots and tubers every 21 days, beginning at early tuber growth and continuing until vine kill. Tuber yields, grades, and internal quality measurements were determined for each plot.

Soil-Applied K Effects

The overall tendency was for K applications to increase both total yields as well as yield and percent of >10 oz. tubers for all studies in which exchangeable soil K ranged from 85 to 131 ppm (**Table 1**). Potash applications slightly decreased specific gravity in two of three studies. However, slightly higher gravity usually occurred where K_2SO_4 was the K source (averaged across all other treatments) which is consistent with previous research by the authors in Utah. Potato tuber yields were comparable for both K sources. The highest tuber yields in 1992 were recorded at the highest K rate (480 lb K_2O/A), while the highest K rate (720 lb K_2O/A) in 1994 tended to decrease yield (**Table 2**). Growers who apply such high rates of K should consider a split application to help eliminate the possibility of detrimental salt effects. A portion of the material could be applied in the fall with the remainder in the spring.

Fertigation K Effects

Growers who are concerned with adequacy of K fertilization should plan ahead so they can apply all of their K on a preplant basis (**Table 3**). There was no evidence that in-season fertilizer K benefited production or tuber quality over a preplant program. Rates of either 30 or 60 lb K_2O/A or different sources of K made no difference to plant response for in-season K applications (data not shown).

Petiole K Concentrations

Petiole K concentrations decreased with time after tuber initiation. Concentrations were initially higher with broadcast K applications compared to either banding or fertigation treatments. Concentrations for split applications were moderate and K_2SO_4 applications tended to produce higher petiole K concentrations than other sources. Petiole K concentration response to fertigation application was slow...15 to 20 days after application. The relationship between the petiole

TABLE 2. *Effect of preplant broadcast KCl and K_2SO_4 on tuber yields and specific gravity.*[a]

K Source	K_2O, lb/A	Yield parameters, cwt/A Total	US #1	Large US #1	>10 oz, %	Specific gravity
				1992		
	0	416a	324a	73a	19.9a	1.083b
KCl	120	429ab	351ab	101ab	25.9b	1.083b
KCl	240	429ab	337a	105ab	28.4b	1.081ab
K_2SO_4	240	451b	374b	115b	27.7b	1.082ab
KCl	480	445b	373b	118b	29.8b	1.080a
				1994		
	0	408ab	296bc	82	29.8a	1.082b
KCl	180	421b	310c	91	29.6a	1.079a
K_2SO_4	180	401a	282b	94	33.0ab	1.081ab
KCl	360	419b	285b	100	35.1b	1.082b
K_2SO_4	360	450c	312c	102	32.9ab	1.078a
KCl	720	389a	256a	93	35.9b	1.077a

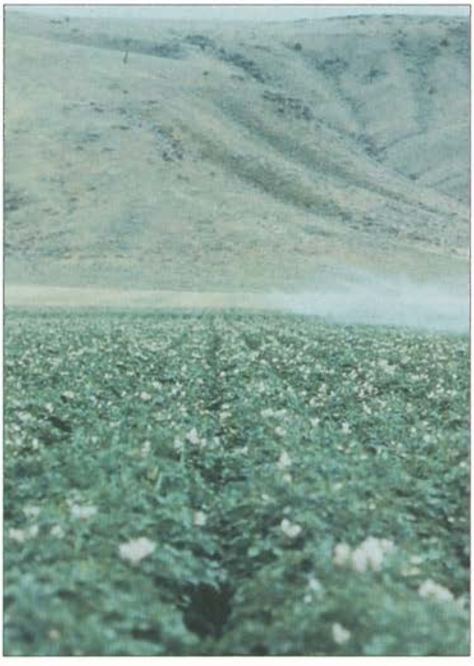
[a] **Means within the same column and experiment followed by different letters are significant at $P \leq 0.05$.**

K concentration and K uptake rate balance (total plant uptake/tuber uptake) showed average K concentrations of 6.4 percent when the K balance was "1". This balance tended to range from 5.5 to 7.2 percent K depending on tuber growth rate. Growers can use this range as a guide to K sufficiency for irrigated Russet Burbank production in southern Idaho. However, to avoid any potential in-season K deficiency during tuber bulking, growers should not allow the fourth mature petiole to drop below 7.2 percent K.

Summary

These studies support the current soil test K critical levels provided by the University of Idaho. However, recommended K fertilization rates for potatoes should be increased over what is presently considered adequate. This is particularly true on coarse, sandy textured soils.

Potassium fertilization increases large tubers as well as total tuber production in



IDAHO *researchers are showing that rates of fertilizer K for potatoes may need to be increased for better yields and quality.*

most years when soil test K levels fall below established critical levels. Potassium sources have little effect on total tuber yields, but K_2SO_4 applications produced a higher percentage of larger tubers and a trend towards higher specific gravity. Growers should apply the total K fertilizer requirements on a preplant basis where possible. Higher rates of K should be split into a fall and spring application. Growers who monitor K petiole concentrations should fertigate with K if concentrations drop below 7.2 percent in the fourth mature petiole. The total rate per individual injection should not exceed 30 lb K_2O/A during tuber growth. Late season (30 days prior to vine kill) K fertigation applications are probably not effective. BC

TABLE 3. *Effect of K application method on tuber yields and specific gravity averaged across K sources.*[a]

Yield parameter	1992 240 lb K_2O/A Preplant	1992 240 lb K_2O/A Split	1994 360 lb K_2O/A Preplant	1994 360 lb K_2O/A Split
Total, cwt	429b	388a	434	412
US #1, cwt	337b	298a	298a	315b
Large US #1, cwt[a]	105b	72a	101b	82a
>10 oz, %	28.4b	21.9a	34.0b	26.9a
Specific gravity	1.081	1.081	1.079	1.079

[a] **Means within the same row and experiment followed with different letters are significant at $P \leq 0.05$.**

Dr. Tindall is Extension Soils Specialist, University of Idaho, Twin Falls, and Dr. Westermann is Soil Scientist, USDA-ARS, Kimberly, ID.

North Central Soil Fertility Conference Proceedings Available

Papers of the 1995 North Central Extension-Industry Soil Fertility Conference are available for interested individuals. The Conference, held in St. Louis, MO, November 15-16, was the 25th annual opportunity for agriculturalists from the North Central region of the U.S. and Canada to be updated on the latest developments in soil fertility research and education. The North Central region includes the states of North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Kentucky, Indiana, Michigan, Ohio, Pennsylvania and the province of Ontario.

The proceedings of the Conference include presentations on site-specific crop management, improved fertilizer recommendations for nitrogen, phosphorus, potassium, sulfur and zinc, the importance of starter fertilizers for reduced tillage crops, residue interactions with starter fertilizer needs, corn hybrid interactions with starter fertilizer applications, management considerations for returning conservation reserve program (CRP) land to production, systems research for higher yields, efficiency and profits in corn-wheat-doublecropped soybean rotations plus a number of other important topics and reports.

The Conference also encourages graduate student participation and recognition. 1996 Graduate Student Awards were presented to Rogerio Borges, Iowa State University; Jon Charlesworth, Purdue University; Jason Goesch, University of Nebraska; Marcus Jones, Michigan State University; Luiz A. C. Lucchesi, Ohio State University; Karl Ritchie, University of Illinois; Kevin Schoessow, University of Wisconsin; Michael Smith, North Dakota State University; Tad Wesley, Kansas State University; and Terry Wilkerson, Southern Illinois University.

Dates for the 1996 North Central Extension-Industry Soil Fertility Conference are November 20-21 at the Westport Holiday Inn in St. Louis, MO.

Copies of the Conference proceedings are available at a price of $15 in U.S. funds from the Potash & Phosphate Institute, 2805 Claflin Road, Suite 200, Manhattan, KS 66502, phone 913-776-0273. BC

ARKANSAS

Potassium Deficiency and Plant Diseases Observed in Rice Fields

By N.A. Slaton, R.D. Cartwright and C.E. Wilson, Jr.

Potassium deficiencies in rice were once thought to be rare in Arkansas. However, since 1991 the frequency of K deficiency has increased. Two main theories concerning the recent increase in visual symptoms of K deficiency have been proposed. One involves a gradual reduction in soil test K values over time, the other the release of new, high yielding varieties that may require high soil K levels.

A summary of University of Arkansas Soil Testing Laboratory results (1994-95) for rice indicates that 44 percent of the state rice acreage requires direct K fertilization based on soil test levels less than 175 lb K/A (Mehlich 3). Additionally, 12 percent of the total acreage tests less than 125 lb K/A.

Visual K deficiency symptoms and depressed yields are very likely on soils testing below 100 lb K/A. Visual symptoms include yellowing of leaf tips and margins (normally beginning in the lower canopy), stunted plant growth, reduced tillering, black and deteriorated root systems, and reduced response to midseason topdress nitrogen (N) applications. Plant deficiency symptoms usually begin to appear about midseason when yellowing of rice plants is normally attributed to N deficiency. In severe K deficiencies, leaf die-back will proceed from leaf tips down nearly to the base of upper leaves. Potassium deficiency normally proceeds through a series of leaf color changes, depending on cultivar, including yellow, reddish brown, and eventually a tan/brown color resulting from leaf death. Premature leaf death and accompanying color changes often are a result of increased damage from various rice diseases.

Although potassium (K) deficiencies in rice were once thought to be rare in Arkansas, the frequency has been increasing. Severe disease problems are often associated with K deficiency.

Brown spot *attacks the panicle of K-deficient rice.*

Potassium and Rice Diseases

Growers often notice severe disease problems on K-deficient rice rather than the early leaf symptoms typical for K-deficient plants. Therefore, they frequently interpret K deficiency as a disease problem rather than a nutrient deficiency. Diseases that are normally not significant problems, such as brown leaf spot (*Bipolaris oryzae*), scab (*Fusarium graninearum*), and stem rot (*Sclerotium oryzae*) overwhelm K-deficient rice. Analysis of diseased panicles from K-deficient fields in 1994 indicated that brown

TABLE 1. *Selected parameters from tissue analysis of rice affected by K deficiency symptoms in 1994.*

Visual damage	Number of samples	Nutrient, %[a]					Nutrient, ppm[e]		N/K[d] ratio
		N	P	K	Ca	Mg	Na	Mn	
None[b]	8	1.75	0.18	1.16	0.71	0.20	488	1,679	1.5
Moderate	11	2.37	0.29	0.91	0.69	0.24	1,490	1,104	2.6
Severe	14	2.08	0.27	0.45	0.67	0.26	2,627	899	4.6
Critical values (>)[c]		3.00	0.20	1.50	0.20	0.15	–	40	–

[a] Tissue was sampled near plant maturity.
[b] Data collected and provided by Dr. Rick Cartwright.
[c] Critical values were taken from Sedberry, J.E., Jr., M.C. Amacher, D.P. Bligh, and O.D. Curtis. Plant-Tissue Analysis as a Diagnostic Aid in Crop Production. Louisiana State University Agricultural Experiment Station, Bulletin No. 783.
[d] N/K ratio of plant tissue.
[e] ppm = parts per million

spot was found on up to 90 percent of the grains and contributed the largest amount of yield reduction among diseases. Scab was isolated on up to 20 percent of grain from infected panicles. Other minor diseases were also isolated on affected panicles, including black kernel (*Curvularia lunata*) and Fusarium sheath rot (*Fusarium proliferatum*). Stem rot is a sheath/stem disease that is aggravated by K deficiency. Stem rot causes premature death of tillers and partial blanking of panicles, especially in K-deficient plants.

In most K-deficient rice fields that follow flood irrigated soybeans in rotation, the borrow ditch area of the previous year's soybean levees produces near normal growth. (Levees are graded level with the field after each crop.) The pattern appears as two parallel streaks of "healthier" rice ranging 12 to 18 inches in width and about 4 to 6 feet apart. Soil from the previous year's levee had no plant growth to mine soil K reserves. Since K values normally decrease with soil depth, rice growing in a borrow ditch for the current crop is usually most affected by K deficiency symptoms. This is probably due to low K values in the subsoil exposed by levee formation. Other factors considered to increase the likelihood of K deficiency include rice water weevil larvae (*Lissorhoptrus oryzophilus K*) damage to the rice root system, differences among cultivar K requirements, and inappropriate soil sampling procedures that do not accurately represent the soil fertility status.

Arkansas Conditions

Potassium deficiencies on rice in Arkansas are most likely to occur on sandy and silt loam fields following irrigated soybeans. Crop removal of K is high under intensive management for top soybean and rice yields. Nutritionally healthy rice at panicle differentiation should be greater than 1.5 percent K. **Tables 1** and **2** provide plant and soil analysis data from deficient fields sampled in 1994. Potassium-deficient rice showing severe symptoms commonly has K levels less than 0.5 percent K, high N/K ratio, high sodium (Na) concentrations, and lower manganese (Mn) levels. Limited information is available on yield reductions due to K deficiency, especially if diseases are present. Field observations suggest that grain quality and yield reductions of 50 to 80 percent are possible from K deficiency coupled with severe disease damage. Historically, severely affected areas are usually small in size, but in 1994 entire fields

TABLE 2. *Selected parameters from soil analysis of rice fields affected by K deficiency symptoms in 1994.*

Visual damage	Number of samples	pH[b]	P	K	Ca	Mg	Na	Mn
		Soil parameter measured[a]						
			lb/A[c]					
None[d]	5	6.1	27	164	2,973	571	122	377
Moderate	7	5.9	28	62	1,744	280	91	127
Severe	9	5.8	22	62	1,797	318	83	188

a Soil samples were taken near plant maturity.
b pH values of flooded soil samples, dried in the laboratory.
c University of Arkansas Soil Test Laboratory – Mehlich 3 extract.
d Data collected and provided by Dr. Cartwright.

were affected.

Two factors were common upon field examination of K deficiencies in grower fields...many growers did not have recent soil test results and many soil samples represented too large an area to account for soil variability. Educational programs have been implemented in county Extension grower meetings to address these problems. The main focus of educational efforts has centered on the correct use of soil test procedures in determining soil fertility status in rice/soybean rotations and early identification of K deficiency symptoms. Research projects are underway to evaluate University of Arkansas soil test K recommendations, determine yield loss potential due to low soil K values, evaluate the possibility of differences among rice variety K requirements, and compare application timing of K fertilizer to rice. Observations of disease incidence are also being taken from K fertilization research.

STEM ROT *takes a heavy toll on K-deficient rice.*

Educational efforts thus far have led to increased soil testing and use of phosphorus (P) and K fertilizers on the 1995 rice crop, especially on the coarser soil textures in areas having severe disease epidemics in 1994. While not a total cure, the impact of this improvement to balanced rice nutrition has apparently already had a positive effect. For instance, dozens of K-deficient fields with severe disease damage were noted in 1994 in northeast Arkansas by the second author, whereas fewer than 10 have been observed in 1995. BC

Mr. Slaton is Area Rice Specialist, University of Arkansas Cooperative Extension Service. Dr. Cartwright is Research Assistant Professor of Plant Pathology, University of Arkansas. Dr. Wilson is Extension Rice Specialist and Research Assistant Professor of Agronomy, University of Arkansas.

The authors wish to acknowledge the following Arkansas county Extension agents for their contributions to this work: David Annis, Ron Beaty, Henry Chaney, Randy Chlapecka, Stephen Culp, Roger Gipson, Eric Grant, Quinton Hornsby, Lee Hunter, Mark Phillips, Ray Siler, Scott Taylor, Brannon Theisse, Rick Thompson, and Chuck Wisdom. Our thanks also to Paul Dickson, Nancy Wolfe, Dr. Wayne Sabbe, Dr. B. R. Wells, Dr. Cliff Snyder, and Dr. R. J. Norman for technical support and advice.

J. Fielding Reed PPI Fellowships... A Heritage of Higher Learning

Fifteen years ago the Potash & Phosphate Institute (PPI) established a program of fellowships for students seeking advanced degrees (M.S. or Ph.D.) in soil and plant sciences and related academic fields. In 1987, the PPI Board of Directors named the grants the "J. Fielding Reed PPI Fellowships" in recognition of Dr. Reed, President of the Institute from 1963 to 1975.

Dr. Reed's lifetime commitment to agronomic improvement has been fundamental to his dedication to soil testing as a diagnostic tool. Working closely with the American Society of Agronomy and the university system, he was responsible for establishing several soil and plant analysis laboratories. In the early 1950s he was instrumental in organizing the Georgia Plant Food Educational Society, promoting educational programs on proper fertilizer use. His influence has helped numerous groups and individuals from academic to industry to production and other interests.

Since the first $2,000 Fellowship was awarded in 1980, there have been 99 recipients representing 36 different universities. Dr. W.R. Thompson, Jr., PPI Midsouth Director (retired October, 1995), chaired the selection committee through 1995. The challenge involved evaluating 653 applications, appropriate transcripts, supporting letters and related information from candidates at 83 universities.

The selection process for the "J. Fielding Reed PPI Fellowship" will now be handled by a committee chaired by Dr. Albert E. Ludwick, PPI Western Director. The Potash & Phosphate Institute is proud to continue the award to students with a preference in soil fertility, soil chemistry and plant nutrition, based on merit, scholarship, research projects and activities. BC

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Donald L. Armstrong, Editor

OHIO

Adequate Soil Potassium Increases Nitrogen Use Efficiency by Corn

By J.W. Johnson and H.F. Reetz

Developing sound nutrient management plans for crop production requires understanding of the response relationships to the various nutrients. Response curves for N, phosphorus (P), and K are readily available for many situations to help with this understanding. But the interactions among the nutrients are also important considerations. Adequate data sets are more difficult to find. A detailed study at the Ohio State University Western Research Center, Springfield, OH, is providing valuable information on the interactions of K and N.

Higher soil test potassium (K) levels resulted in significant yield response, higher optimum applied nitrogen (N) rates, more efficient use of the applied N and less nitrate-N remaining in the soil after harvest.

Interaction

The experiment was designed to determine the interaction between applied N and residual soil K on corn yield and on the efficiency of N use by corn. The study is being conducted on a Crosby silt loam soil, representative of a large part of the eastern Corn Belt. The soil has a cation exchange capacity (CEC) of 12 milliequivalents/100g. October 1994 soil tests showed an average pH of 6.5 and an average Bray-P_1 soil test of 39 lb/A. All plots received annual preplant broadcast applications of 50 lb P_2O_5/A. In 1992, five K treatments were established as the main plots in a split plot design and annual soil tests were used to monitor K levels. Six different N treatments were established as the split plots. Annual N applications in 80 lb/A increments ranged from 0 to 320 lb/A, with all except the check plot receiving 40 lb N/A as starter and the rest applied as preplant broadcast ammonium nitrate.

Figure 1 shows the interaction between N rate and soil test K level on corn yield. There was a positive yield response to at least 160 lb N/A and to soil test K levels of up to 232 lb K/A. When no N was applied, the optimum soil test K was below 200 lb K/A. However, when soil test K was above 200 lb K/A, the optimum N rate was between 160 and 240 lb N/A.

The concentration of N in the corn grain increased as N rate and soil test K level increased. The combination of higher yield and higher percent N in the grain resulted in significantly higher total N removed in the grain (**Table 1**). As N rate increased, the percent of total applied N removed in the grain decreased (data not

TABLE 1. *Nitrogen in grain as influenced by applied N and soil K level.*

N rate,	Soil test K, lb/A				
lb/A	160	200	232	269	278
	N in grain, lb/A				
0	68	74	65	55	60
80	91	107	114	105	105
160	101	120	141	137	139
240	114	127	138	145	147
320	125	136	144	151	147

Ohio, 1992-1994, 3-yr. average

shown). But, at all N rates, higher soil test K levels resulted in a higher percentage of the total applied N being removed in the grain. That means higher N use efficiency. Similarly, increasing soil test K levels resulted in increased uptake of applied N in the total plant (**Table 2**).

TABLE 2. *Increasing soil test K levels resulted in increased uptake of applied N in the total plant.*

N rate, lb/A	Soil test K, lb/A 160	200	232	269	278
	Percent of applied N in total plant				
80	60	88	73	97	103
160	44	57	70	80	89
240	27	36	40	57	58
320	30	37	31	52	45

Post-harvest soil sampling revealed that increasing N application rates resulted in a higher percentage of the total applied N being left in the soil (0-3 ft.) at the end of the season (**Figure 2**). As soil K test level increased, more of the N was taken up by the crop, and significantly less remained in the soil. When soil K levels were above 232 lb K/A, the crop utilized fertilizer N more efficiently, resulting in less nitrate-N remaining in the soil after harvest.

Summary

The interaction between soil test K and N use efficiency demonstrates that K soil test should be maintained at high levels for higher yields and to make best use of available N. Any on-farm studies to determine optimum N rates should be conducted with high levels of available K. Otherwise, optimum yields and optimum N use efficiency will not be obtained.

When interpreting N response data to be used in formulating nutrient recommendations, it is critical to know that soil test K levels are high enough to optimize the interaction effects demonstrated in this study. If soil test K levels are below optimum, the full benefit of applied N cannot be realized, and more of the applied N may be left in the soil after harvest, resulting in lower profitability and creating greater potential for a negative environmental impact. BC

Dr. Johnson is Professor of Soil Fertility, School of Natural Resources, The Ohio State University, Columbus, OH. Dr. Reetz is Midwest Director, PPI, Monticello, IL.

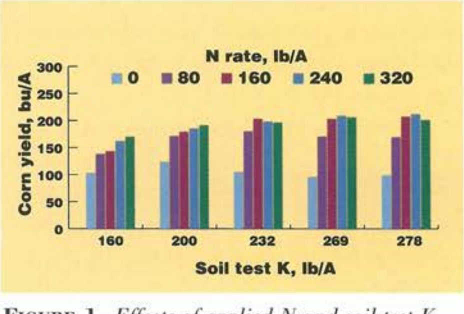

FIGURE 1. *Effects of applied N and soil test K on average corn yields. Springfield, OH, 1992-1995*

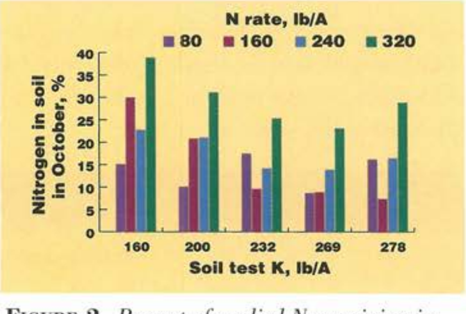

FIGURE 2. *Percent of applied N remaining in soil in October, related to soil test K level.*

CALIFORNIA

Foliar Applied Potassium Benefits Cotton in the San Joaquin Valley

By Bill L. Weir, Robert Miller and Bruce Roberts

California produces about 20 percent of U.S. upland cotton annually on 1.25 million acres. There are currently 11 different varieties available for growers to choose from. They are grown on a wide variety of soil types and with diverse management practices.

Along with new varieties have come new technologies and changes in cultural practices. Plant growth regulators such as PIX (mepiquat chloride) and PGR IV (gibberellic acid and indobuteric acid) may improve yields by aiding in setting and retaining more bolls. Earlier application of the first irrigation to avoid moisture stress has also been beneficial to yields and has enhanced the positive response derived from the plant growth regulators. Intensive crop monitoring has become standardized and is used extensively for pest management and for monitoring progression of the crop.

Studies in California indicate that mid-season potassium (K) deficiency in cotton can be avoided with foliar sprays. Rates of less than 10 lb/A of K_2O can produce a highly economical return.

The application of foliar nitrogen (N) and K at or near the early bloom stage of growth, when these nutrients are in peak demand, is a recent practice that is gaining in popularity. Since 1983, such innovations in fertilization and other inputs, cultural practices, and overall management have resulted in an average annual cotton yield increase of 32 lb lint/A in California.

Cotton plants require K at a rate of 1.9 to 3.0 lb/A/day during boll fill. Previous studies by University of California researchers (Dr. Ken Cassman and others) have demonstrated that these levels of K uptake can be difficult to maintain, especially on vermiculitic soils in the San Joaquin Valley. After years of K depletion (inadequate fertilization), the high K buffering capacity of these soils results in conditions in which very large amounts of soil applied K are fixed.

Growers of the San Joaquin Valley are aware of the need to be efficient with fertilizer in the sense of minimizing K fixation by the soil as well as preventing losses of nutrients, primarily N, to the groundwater and to the atmosphere. Innovative methods of fertilizer applications such as split sidedress, water run, and

TABLE 1. *Test site characteristics.*

Test	Variety	Exchangeable K[1], ppm	Release rate[2], ppm/day
Merced 1992	Royale	160	2
Kings 1992	Pima S-6	159	–
Merced 1993	Maxxa	145	2

[1] In ammonium acetate.
[2] Unocal procedure.

foliar applications are becoming common. The increasing interest in supplemental applications of N and K by foliar applications is creating many questions that must be answered by researchers.

San Joaquin Valley Studies

Field tests were conducted in 1992 and 1993 in Merced and Kings counties in which K was applied in foliar sprays at various times during the growing season. All treatments were replicated four times. In Merced County, one test was conducted with potassium sulfate (K_2SO_4) and two with potassium nitrate (KNO_3).

Treatments were applied by a tractor sprayer set up for foliar plot work. Plots were eight rows wide (30-inch centers) by one-fourth mile long. Five treatments consisted of foliar applications initiated after first flower at timings of: 1 and 2 weeks; 3 and 4 weeks; 5 and 6 weeks; 7 and 8 weeks; and a control. Each of the two applications consisted of materials applied at the rate of 4.5 lb/A of K_2O, so that each treatment received a total of 9 lb/A. Acala Royale and Acala Maxxa were evaluated in the study. Plots were harvested with the grower's straddle row 30-inch picker and weighed with a research scale.

Similarly, the Kings County trials tested the yield response of Pima S-6 to foliar KNO_3 applied after first bloom at: 1, 3, 5, and 7 weeks; 3 and 4 weeks; and 5 and 6 weeks. A fourth treatment consisted of foliar K applied at 3 and 4 weeks to plants growing on soil fertilized preplant at the rate of 360 lb/A of K_2O using potassium chloride (KCl). Foliar applications went on as KNO_3 at the rate of 4.5 lb/A of K_2O which totaled 9 lb/A after two applications and 18 lb/A after four applications. This test was conducted by hand spraying plots four rows wide (38-inch centers) and hand harvesting 13-foot lengths from the center two rows for yields.

The cotton varieties used and the available soil K values for each experimental site are presented in **Table 1**. All sites were adequate in exchangeable K according to present University of California guidelines. The K release test also suggests adequate release potential.

Results

The Merced and Kings counties tests in 1992 evaluated the importance of timing of foliar KNO_3 (unbuffered solution) on both upland and Pima varieties (**Table 2**). Data in **Figure 1** show that applica-

TABLE 2. *Foliar KNO_3 application effects on yields of Acala and Pima cottons, 1992.*

Application, weeks after first flower	7/1	7/7	7/16	7/22	7/28	8/4	8/12	8/20	Lint yield, lb/A
				Treatments dates					
Acala (Merced)									
Control	–	–	–	–	–	–	–	–	1,291
1 & 2	+	+	–	–	–	–	–	–	1,360
3 & 4	–	–	+	+	–	–	–	–	1,411
5 & 6	–	–	–	–	+	+	–	–	1,367
7 & 8	–	–	–	–	–	–	+	+	1,313
Pima (Kings)									
Control	–	–	–	–	–	–	–	–	1,310
1-7	–	+	–	+	–	+	–	+	1,371
4 & 6	–	–	–	–	+	–	+	–	1,332
5 & 7	–	–	–	–	–	+	–	+	1,255
360 lb K_2O/A soil	–	–	–	–	+	–	+	–	1,397

tions of KNO_3 at about three weeks after bloom resulted in greater yields than either earlier or later applications. The highest yield in the Pima test when there was no soil applied K treatment occurred with four sequential applications at 1, 3, 5, and 7 weeks after first bloom. The yields were not significantly different, but the trend supports the results from the upland tests.

The 1993 tests employed both KNO_3 and K_2SO_4 applied foliarly (unbuffered solutions) to Acala Maxxa cotton in Merced County and KNO_3 applied to Pima S-7 in Kings County. Results from these tests were very similar to those of the previous year. The greatest yield responses were measured from plots receiving foliar K at 2 to 3 weeks after bloom initiation. Yield response was less as foliar applications were made later in the season. The effect was similar whether the K fertilizer source was KNO_3 or K_2SO_4.

NEW COTTON *varieties which set a heavy boll load over a short period of time require larger amounts of K. High yield management of these varieties has led to widespread occurrence of K deficiency symptoms during mid and late season in the San Joaquin Valley.*

Summary

The results of these tests show that benefits can be obtained from foliar applications of K. New, more determinant cotton varieties which set the crop over a short period of time require larger amounts of some nutrients, such as K and N, during this critical stage of development. These varieties coupled with cultural practices aimed at obtaining high yields and which push the crop toward earlier termination also intensify nutrient demand. One result has been the widespread occurrence of K deficiency symptoms in cotton fields during mid- and late-season. Even though soil K levels are "adequate" according to present guidelines, foliar applications at 2 to 3 weeks after first bloom produce a positive yield response. BC

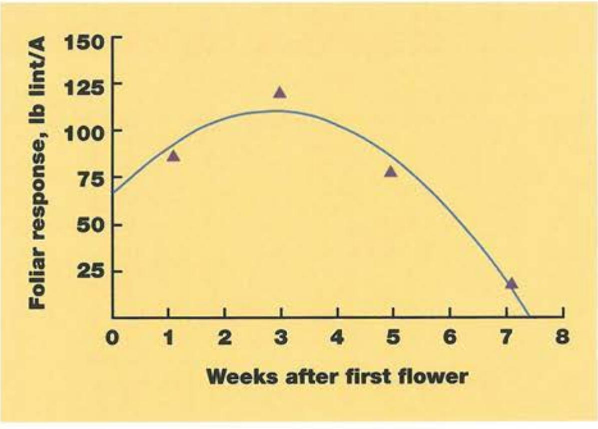

FIGURE 1. *Cotton response to foliar-applied K at various times after first flower.*

Dr. Weir is Extension Farm Advisor, Merced County, Dr. Miller is Extension Soils Specialist, University of California, Davis, and Mr. Roberts is Extension Farm Advisor, Kings County, California.

Dr. N.R. Usherwood Receives SSSA Professional Service Award

Dr. Noble R. Usherwood, Southeast Director of PPI and Vice President of the Foundation for Agronomic Research, received the Soil Science Professional Service Award at the 1995 annual meeting of the Soil Science Society of America (SSSA) recently in St. Louis.

The award recognizes outstanding achievements in soil science through education, research, and national and international service.

Dr. Usherwood earned degrees from Southern Illinois University and the University of Maryland. He is a Fellow of the American Society of Agronomy (ASA), the Crop Science Society of America, and SSSA. He received the 1990 ASA Agronomic Industry Award, and has often been recognized for his service at state and regional levels. He served as Board Chair of the Agronomic Science Foundation and on the National CCA Council, as Chair of the Georgia State CCA Board, as a teacher of basic principles of soil science to industry, on university and industry advisory boards, and on many SSSA committees. BC


Dr. N.R. Usherwood

Dr. James D. Beaton Elected Honorary Member of CFI

The Canadian Fertilizer Institute Board of Directors has elected Dr. James D. Beaton as an Honorary Member. The award was presented during the annual summer convention of CFI in August.


Dr. J. D. Beaton

"Dr. Beaton has accomplished an important role in representing the fertilizer industry, both in Canada and internationally," said Roger L. Larson, Managing Director of CFI .

Before his retirement in 1994, Dr. Beaton served as Senior Vice President for International Programs of PPI and President of the Potash & Phosphate Institute of Canada (PPIC). Dr. Beaton's career included positions in university, government, industry and various associations. PPI/PPIC international programs flourished under his direction.

A prolific researcher and writer, Dr. Beaton was involved with a wide spectrum of papers and presentations on agronomic subjects. A native of British Columbia, he is co-author of the widely used textbook, *Soil Fertility and Fertilizers*, now in its fifth edition.

Dr. Beaton and his wife, Doris, live in Kelowna, BC. BC

CALIFORNIA

Potassium Nutrition of Processing Tomato

By T.K. Hartz

Processing tomato, a major crop in California, has a very high K requirement. Potassium uptake on a high yield crop can exceed 400 lb/A, the majority of which is in the fruit. All current cultivars have a strongly determinate growth habit, concentrating fruit set in a 3 to 4 week period. Peak K uptake, which corresponds to the rapid fruit bulking period, can exceed 10 lb K/A/day. In a 1993-94 survey of approximately 100 processing tomato fields, K was identified as the most frequently limiting nutrient. Beyond direct yield-limiting effects, K availability has been linked to important fruit quality factors such as soluble solids content and color.

In a 1993-94 survey of approximately 100 processing tomato fields in California, potassium (K) was identified as the most limiting nutrient. Follow-up studies have illustrated the utility of determining the soil K release rate and fixation potential in formulating a K fertilizer management plan. Water-run K is effective in supplementing the K supply during peak crop demand and appears especially beneficial for soils with a high K fixing capacity.

Over the years, numerous K fertilizer trials on processing tomato have been conducted in California with mixed results. There are two factors which may help explain the often contradictory results...the way in which soil K supply is evaluated, and the method of K application. Historically, a standard extraction technique (ammonium acetate or equivalent) has been the most common measure of soil K availability. Extraction procedures, while useful, present a one-dimensional picture of soil K supply. In reality, soil K availability is a dynamic process.

There are three interlocking pools of soil K that impact plant availability: K in soil solution, K on exchange sites, and K trapped in interlayer sites of clay minerals.

Soil Test K Comparisons

A comparison of soil test methods to evaluate K dynamics was conducted on approximately 80 soils representative of central California conditions. The three techniques evaluated were ammonium acetate extraction, K release rate, and K fixation potential. Potassium release rate was measured by a seven day incubation of a 1:10 mixture of soil and 0.01M $CaCl_2$...K in solution was reported as parts per million (ppm) release per day. To assay K fixation, 390 ppm K (as KNO_3 solution) was thoroughly blended with soil to create a slurry, which was air-dried to simulate a typical field wetting/drying cycle. This K-enriched soil sample was subjected to a seven day incubation in $CaCl_2$ as previously described, then extracted in 1N NH_4Cl. Added K not recovered was considered to be fixed.

Ammonium acetate extractable K and K release rate were correlated but individual soils differed dramatically from the general relationship. Since plants obtain most K from soil solution, K release rate

TABLE 1. *Response of processing tomato to water-run K application.*

Site	Soil parameters: Ammonium acetate extractable K, ppm	K release rate, ppm/day	K fixation, %	Fruit yield, tons/A: Treated	Control
Tracy	100	2.6	60	31.2*	27.4
Sacramento	123	3.1	20	38.3*	36.9
Dixon	205	5.2	0	42.0NS	40.2
UCD	284	8.5	0	53.1NS	51.9

***Significant at p=.05**
NS Not significant

may be a more appropriate procedure to evaluate a soil's ability to meet crop uptake at peak demand. The ability to fix added K differed widely among soils. A majority of soils tested fixed little or no K, about 30 percent exhibited a modest level of fixation, while 10 percent had very high fixation capacity. As expected, K fixation was mostly a phenomenon of soils with limited K supply (<150 ppm extractable), but there was considerable variability in fixation potential among low K soils.

Field Trials

Four K fertilizer trials were conducted in 1994. They measured the response of processing tomato to modest K amounts delivered in irrigation water during peak crop demand. The sites were chosen to exhibit a range of soil K availability and fixation values. At three sites, two water-run applications of 50 lb K_2O/A each (as KCl) were applied in consecutive furrow irrigation during the late fruit set/early fruit bulking period. At the other site, three weekly applications of 33 lb K_2O/A were applied through drip irrigation during the same phenological period. At each location, four single row treated plots were paired with untreated plots in randomized block design. Once-over, destructive harvest was done to simulate commercial mechanical harvest.

Response to water-run K varied by site (**Table 1**). Modest but statistically significant yield increases were obtained at Tracy and Sacramento, which had the lowest available K values and the highest fixation values. The response at Tracy was particularly heartening, given the high fixation potential.

Previous research has suggested that, using preplant or sidedress applications, very high application rates are required to achieve significant response in soil with high fixation potential. The delivery of K in water at peak crop demand apparently allowed the crop to compete effectively for applied K.

At a contract price of approximately $50/ton of fruit, even a modest yield response made low rate, water-run K application a profitable practice. Tissue and fruit K levels were still marginal in treated plots at both responding sites, suggesting that higher K application rates may be required for maximum response. There was no treatment difference in fruit color or soluble solids content at any site. BC

Dr. Hartz is Extension Vegetable Specialist, Department of Vegetable Crops, University of California, Davis, CA.

Potassium Responses in Northern Forages

By Thomas W. Bruulsema and Jerry H. Cherney

Research has confirmed K needs for economically optimum yields of northern forages.

Northern forages require potassium (K) for optimal yields, but K concentrations in ruminant diets warrant attention. Best management uses soil testing and forage analysis to ensure high yields and persistence. Liming, timing of harvests, species, varieties and age of stand all influence K management in forages.

Alfalfa

An alfalfa K response trial was conducted in Aurora, NY, by S.D. Klausner of Cornell University from 1988 to 1992, continuing a series of soil test calibrations. Six annual rates of K were applied on a silt loam soil testing low in K (69 lb/A). The most economic rate[1] for the four years' production was an annual K_2O application of 260 lb/A, compared to a previous recommendation of 110 lb/A. Recently, New York recommendations for medium textured soils testing low to medium in K have been increased. The most economic rate of K application varied little among the four production years. However, responses increased as the stand aged.

Alfalfa responses in soils with high K test levels were recorded by Dr. D.B. Beegle at two sites in Pennsylvania. Although there was no response the first year, in the second and third production years the most economic rate of K fertilizer increased to 110 and 190 lb/A at Rock Springs and 200 and 260 lb/A at Landisville. The critical K concentration in forage for avoiding yield losses appeared to be between 2.5 and 2.8 percent.

Intensive alfalfa management research was conducted in Ontario by Dr. R.W. Sheard from 1984 to 1986. In the second production year (1986) of a five-cut management system, yields showed a small response to K even though soil test levels were high. In both 1985 and 1986, forage K concentration was increased by fertilizer K. The 1986 response suggested a critical level of 2.7 percent.

TABLE 1. *Response of reed canarygrass to annually applied N and K in Connecticut.*

K_2O applied, lb/A	Fertilizer N, lb/A			Fertilizer N, lb/A		
	100	200	300	100	200	300
	Hay yield, tons/A			K concentration, %		
0	3.6	5.1	5.5	1.73	1.02	0.86
200	3.6	5.9	6.9	2.86	2.73	2.46
400	3.5	5.7	6.7	3.07	3.22	3.20

Allinson, et al.

[1] *Economically optimum rates mentioned in this article assume a price ratio of 3 lb hay per lb of K_2O for alfalfa; 3.75 lb hay per lb of K_2O for grass.*

Forage Grasses

A Connecticut experiment on nitrogen (N) and K responses of reed canarygrass was established in 1983. The soil was a Paxton fine sandy loam with soil test K of 240 lb/A. Initial rates of both N and K_2O were 0, 200 and 400 lb/A for the first two years, during which there were significant responses to N but not to K. From 1985 through 1988, N rates were changed to 100, 200 and 300 lb/A, maintaining the same three K rates. During those four years there were consistent responses to K at the higher levels of N (**Table 1**). Economically optimum rates of N and K_2O were 300 and 200 lb/A, respectively, at which forage K concentration was below 2.5 percent.

Fertilization of mixed grass sods on Bangor and Monarda silt loam soils in Maine produced strong responses. At the optimum N rate of 200 lb/A, an economic response up to 150 lb/A of K_2O was measured (**Table 2**). At that rate of K fertilization, first cut grass averaged less than 2 percent K.

TABLE 2. *Response of grass hay to K in Maine averaged over two locations and three years.*

K_2O applied lb/A	Hay yield, tons/A	K concentration, %
50	3.6	1.37
150	4.1	1.90
300	4.2	2.56

45% timothy, 45% quackgrass, 10% bluegrass.

Brown, et al.

Potassium has traditionally been recognized as essential for persistence of legumes in legume/grass mixtures. Research in New Brunswick has shown that it is also essential for persistence of grasses such as timothy.

On acid soils, application of lime increased forage yields and decreased forage K concentrations (**Table 3**). Dolomitic lime was particularly effective in affecting the ratio of K to magnesium (Mg). Higher Mg concentrations in forage are important in reducing the potential for grass tetany, but K supplies must be monitored to be sure that higher yield potentials can be achieved.

Management Considerations

Potassium responses in both legume and grass forages increase over time as the stand ages. There are several reasons for this:

- higher availability of soil K induced by tillage at establishment
- uniform incorporation of initial K application before seeding
- ability of forages to exploit K deep in the soil

As soil K is rapidly depleted by large removals, the forage crop relies more strongly on annual surface applications of K fertilizer. Split applications of K may help. When all the K is applied in the spring, the first cut tends to have high K.

The relationship between protein and K concentration in forage is important. Potassium is essential both as a counter-ion for nitrate (NO_3^-) uptake, and for the conversion of soluble N compounds into proteins.

Summary

Management that both maximizes economic yield and optimizes forage K concentration requires close monitoring of both plant and soil. Regular forage analysis helps to evaluate the fertilizer program as well as to determine feed management. Soil testing should be at least an annual event. BC

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TABLE 3. *Use of calcitic or dolomitic lime to raise soil pH to 5.7 can reduce forage K concentrations.*

Forage species	Forage K concentration, %		
	No lime	Calcitic lime	Dolomitic lime
Perennial ryegrass	3.4	2.7	2.7
Tall fescue	2.9	2.5	2.4
Orchardgrass	3.6	3.1	2.9
White clover	3.9	2.6	2.7
Red clover	3.5	2.1	2.4

Piers, et al., Purdue

Conversion Factors for Metric and U.S. Units

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

METRIC PREFIX DEFINITIONS

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

TO CONVERT U.S. CROP YIELDS FROM BUSHELS PER ACRE (bu/A) TO METRICS

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

CHINA

Potassium Improves Yield and Quality of Mulberry Leaves

By Fu Jianrong, Zhan Changgeng, Jiang Lina and Wu Zheng

Mulberry leaves are the food of silk worms used in producing raw silk. The mulberry growing area in Zhejiang province, People's Republic of China, has expanded to more than 90,000 hectares as a result of high income opportunities from exporting silk products. Newly developed mulberry production is located mainly in river basin areas, on coarse textured soils with low fertility. In these soils, balanced fertilization is necessary to obtain high yield and good quality leaves.

Recent research shows potassium (K) has positive effects on yield and quality of mulberry leaves used as food for silkworms. Higher K rates appear profitable and deserve further study in field trials.

This report presents recent research results to show the effects of K on both yield and quality of mulberry leaves.

A field trial was conducted on a sandy clay soil derived from alluvial deposit with soil pH of 4.4, organic matter 3.6 percent, and readily available nitrogen (N), phosphorus (P) and K of 205, 44, and 78 parts per million (ppm), respectively.

Potassium treatments, applied as KCl, were: K_0, K_{45}, K_{90} and K_{135}, where subscript numbers indicate K_2O rates, kg/ha. An equal application of 310 kg N and 42 kg P_2O_5/ha was given to all treatments. All P, K and half of the N fertilizer were applied into the furrow between the rows, then covered with soil, on June 5, after pruning of the bushes. The remaining N was applied as topdressing on June 27.

A local mulberry variety, "Tong Xianqin", was used. Leaves were harvested from the first week in July until the first week of October when feeding by the autumn silk worm ended. On average, mulberry leaves were harvested every three days. Fresh leaf weight is reported in **Table 1.**

Potassium markedly increased fresh leaf yield and economic return. Data show that with K application rates of 45 and 135 kg K_2O/ha, total fresh leaf weight increased by 13.1 and 33.4 percent, respectively, compared to the unfertilized check plot. Respectively, the net economic benefit over the control was increased by 823 and 2,101 yuan/ha (US$1=approximately 8.5 yuan). The value:cost ratio (VCR) ranged from 11.7 to 13.7.

The 135 kg K_2O/ha rate on mulberry

TABLE 1. *Potassium improves yield and economic return of mulberry.*

K_2O treatment, kg/ha	Yield, kg fresh leaf/ha	Yield increase, kg/ha	Yield increase, %	K cost, yuan/ha	Net profit, yuan/ha	VCR
K_0	20,957	-	-	-	-	-
K_{45}	23,700	2,743	13.1	60	823	13.7
K_{90}	26,314	5,357	25.6	120	1,607	13.4
K_{135}	27,946	7,007	33.4	180	2,101	11.7

gave the highest net profit at a high VCR (11.7). This is consistent with findings from other crops and suggests the need for further increasing the rate of K fertilization on this type of soil, even though soil analysis did not indicate extreme K deficiency.

TABLE 2. *Potassium affects growth of mulberry plants.*

K_2O treatment, kg/ha	Number of branches/ plant	Height of branches, cm	Diameter of branch base, cm	Leaf area, cm^2	Dry weight of leaves, g
K_0	27	124.5	0.76	15.3	1.32
K_{45}	25	131.5	0.90	16.4	1.48
K_{90}	26	176.1	1.04	18.2	1.51
K_{135}	28	180.5	1.05	19.5	1.46

Potassium promoted the growth of mulberry plants. It was clearly observed that plants treated with K had more uniform growth and erect branches with bigger, fresher, green colored leaves. Data measured at the last harvest indicated that with K application branch height increased by 7 to 56 cm, branch diameter by 0.14 to 0.29 cm, number of leaves per branch by 4.5 to 16.5 (data not shown) and leaf area by 1.1 to 4.2 cm^2. Dry weight of leaves was also improved (**Table 2**). All these contributed to increasing yield.

Potassium also improved quality of mulberry leaves (**Table 3**). In newly matured leaves treated with 90 and 135 kg/ha K_2O, the K content increased by 60 and 80 percent, N by 10.9 and 12.1 percent and P by 8.3 and 16.7 percent, respectively. Calcium (Ca), sulfur (S) and boron (B) tended to increase also in comparison with the K_0 treatment, which demonstrates that balanced fertilization improves the use of nutrients by plants. High K content in leaves enhances production of protein (**Table 3**). In the K_{90} and K_{135} treatments, leaf protein content was 2.7 and 3.0 percent higher compared to the K_0 treatment, while total amino acids increased by 1.9 and 2.0 percent. Specific amino acids such as glutamic, glycine, alamine, valine and isoleucine appeared to be particularly responsive to additional K among those tested.

From results presented, it can be concluded that in coarse textured alluvial soils, increasing K fertilizer input is very profitable. The data also indicate that the level of 135 kg/ha K_2O may not be high enough and that additional rates should be tested to determine the maximum economic yield for mulberry leaves. Since silk production is currently a highly profitable agricultural business, there is urgency to obtain this information.

These data are consistent with results obtained in other crops. It appears that new field trials need to be estab-

TABLE 3. *Potassium affects quality of mulberry leaf (dry weight basis).*

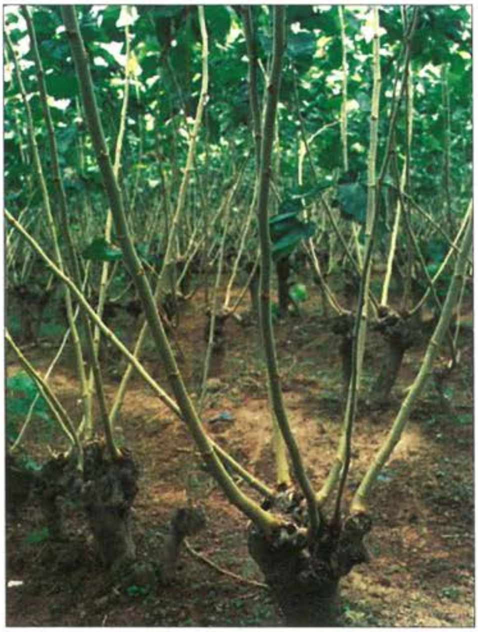
K_2O, kg/ha	N	P	K	Ca	Mg	Zn	Fe	Mn	B	S	Amino acids, %	Protein, %
			%					ppm				
K_0	4.04	0.24	1.36	1.21	0.37	34	114	99	44	499	19.4	25.3
K_{45}	4.03	0.23	1.32	1.30	0.31	41	113	134	46	450	18.8	25.2
K_{90}	4.48	0.26	2.23	1.50	0.29	35	111	50	50	552	21.3	28.0
K_{135}	4.53	0.28	2.45	2.17	0.29	32	145	51	57	617	21.4	28.3

Note: Value of mulberry leaf is 0.3 yuan/kg; KCl cost is 0.8 yuan/kg (K_2O 1.33 yuan/kg).

lished with the various economic crops to establish the maximum economic rate for K_2O. BC

Fu Jianrong, Zhan Changgeng and Jiang Lina are with the Soil and Fertilizer Institute, Zhejiang Academy of Agricultural Sciences, China. Wu Zheng is Director, Soil and Fertilizer Station of Shengxian County, Zhejiang, People's Republic of China.

MULBERRY LEAVES *show positive effects of increasing K_2O rates. From left to right; 1 (no K_2O), 2 (45 kg/ha K_2O), 3 (90 kg/ha K_2O), and 4 (135 kg/ha K_2O).*



MULBERRY PLANTS *shown at left did not receive K fertilization, while plants in photo at right were fertilized. In this research, rates up to 135 kg K_2O/ha were compared. Stems were thicker and stronger with K.*

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Since 1978, PPI has distributed over 75,000 copies of the Soil Fertility Manual. In recent years, there has been growing interest in a version of the manual adapted to international audiences and presented in metric units. Now, PPI is pleased to announce that the 114-page International Soil Fertility Manual is available.

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BRAZIL

Nitrogen and Potassium Fertilization on Sugarcane

By J. Orlando Filho and A.A. Rodella

Brazil more than doubled its sugarcane growing area, from 2 million to over 4 million hectares, in the last 20 years. Much of the expansion is on infertile, sandy soils on which sugarcane is being grown for the first time.

With rapidly expanding areas of sugarcane production, some field trials show significant yield response to nitrogen (N) and potassium (K) in recent studies in Brazil.

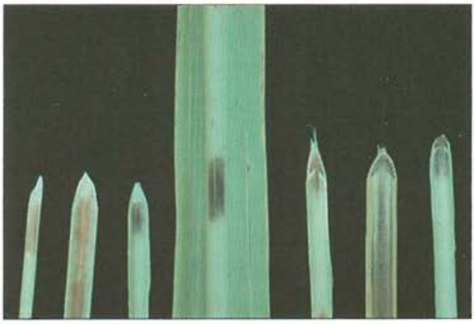
In Brazil, plant cane normally receives very low levels of N (20 to 30 kg N/ha). Nitrogen is applied with K (100 to 120 kg K_2O/ha) in the furrow at planting.

This article reports on responses of plant cane to rates and application timing of N and K on a soil containing 95 percent sand, 0.36 percent carbon (C) and less than 20 parts per million (ppm) K. The soil was limed with 3 t/ha of dolomitic limestone and all treatments received 180 kg P_2O_5/ha in the furrow at planting. Urea and potassium chloride (KCl) were used as sources of N and K, respectively.

The description of treatments and results of cane yields are shown in **Table 1**. Approximately 75 percent of Brazilian research trials involving N in plant cane have not shown significant cane yield responses. Some hypotheses have been suggested to explain the fact.

Plant cane grown in eutrophic (fertile) soils or under minimum tillage has shown response to N application. Also, when soils are planted to sugarcane for the first time, responses to N application are generally detected. This probably occurs due to the restricted supply of the nutrient through atmospheric N fixation in sugarcane roots, since low population of the bacteria *Acetobacter diazothrophicus* prevails under these soil conditions.

The percent pol in juice was not



THIS TRANSVERSE *section of sugarcane midrib red spot shows red rot disease (at right) and potassium deficiency (at left).*

NITROGEN *deficiency on plant cane is shown at left. Normal plant cane is shown at right.*

TABLE 1. *Fertilizer treatments and cane yields.*

Treatments				Cane, tonnes/ha	Pol,%	Fiber,%
1 N, kg/ha	2 N, kg/ha	1 K_2O, kg/ha	2 K_2O, kg/ha			
0	0	0	0	110	15.6	15.0
0	0	90	0	124	16.0	14.3
0	0	180	0	136	16.0	14.2
60	0	0	0	126	16.0	14.0
120	0	0	0	105	15.6	14.7
60	0	90	0	151	15.7	14.2
60	0	180	0	143	15.8	13.6
120	0	90	0	131	16.0	13.4
120	0	180	0	140	16.1	13.6
0	0	45	45	130	16.1	14.2
0	0	90	90	142	16.2	14.0
20	40	0	0	113	16.0	14.3
20	100	0	0	124	15.8	15.7
20	40	45	45	129	15.8	14.2
20	40	90	90	137	16.1	13.8
20	100	45	45	140	15.9	13.8
20	100	90	90	149	16.0	13.5

1 = Application in the bottom of the furrow at planting.
2 = Sidedressed application, four months after planting.

affected by N or K application. However, K reduced percent fiber cane, which is a positive response. Cane yields were also improved by application of N and K. The best result in tonnes cane/ha was obtained with 60 kg N/ha and 90 kg K_2O/ha applied at planting time. This fact is very important because in terms of maximum economic yields in commercial fields, it is possible to eliminate the need for sidedressed NK fertilization. BC

The authors are Professors at CCA-UFSCAR, Araras-SP, Brazil and ESALQ/USP, Piracicaba-SP, Brazil, respectively.

PPI (INPOFOS) Ecuador Office Moves to New Location in Quito

The office of the Northern Latin America Program of PPI has a new location. Also known as INPOFOS (Instituto de la Potasa y el Fosforo), the program is directed by Dr. José Espinosa.

"Changing needs dictated this move. We are optimistic that the improved facilities of the new office location will help us maintain and even improve our effectiveness and productivity in agronomic research and education programs of this important region," said David W. Dibb, President of PPI.

The new address and phone numbers are:

INPOFOS
Gaspar de Villarroel 154 y Eloy Alfaro
Casillo 17-17-980
Quito, Ecuador
Phone: 593-246-3175
Fax: 593-246-4104

POSITIVE POTASSIUM

A Banana a Day Keeps the Cardiologist Away

A recent article in *Cell*, a recognized scientific journal, featured research dealing with cardiac arrhythmia. The critical role of potassium in treating this heart condition was emphasized.

A prominent biochemist, in another article, stressed potassium's importance in human nutrition–called it the most neglected of all mineral elements. The best way to provide it is through foods high in potassium–such as bananas, potatoes, tomatoes or citrus fruits. And food can't contain adequate amounts of any needed element unless the medium in which plants grow supplies it.

Well, so what's this got to do with agriculture and the fertilizer industry? A lot, if we would just recognize it. It's a **positive** for an industry that spends too much of its energy countering negatives.

Food production and fertilizers have a great deal going for them. We should promote these–capitalize on their value–instead of apologizing for the words "chemicals" and "fertilizers".

We can devote our efforts to defending our products from the unfounded tirades of environmental radicals–or better to pointing out the great contributions and essentiality of agriculture and chemicals.

Do we ourselves realize how vital we are to global health and world freedom?

J. Fielding Reed

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