BETTER CROPS
WITH PLANT FOOD

Spring 1989

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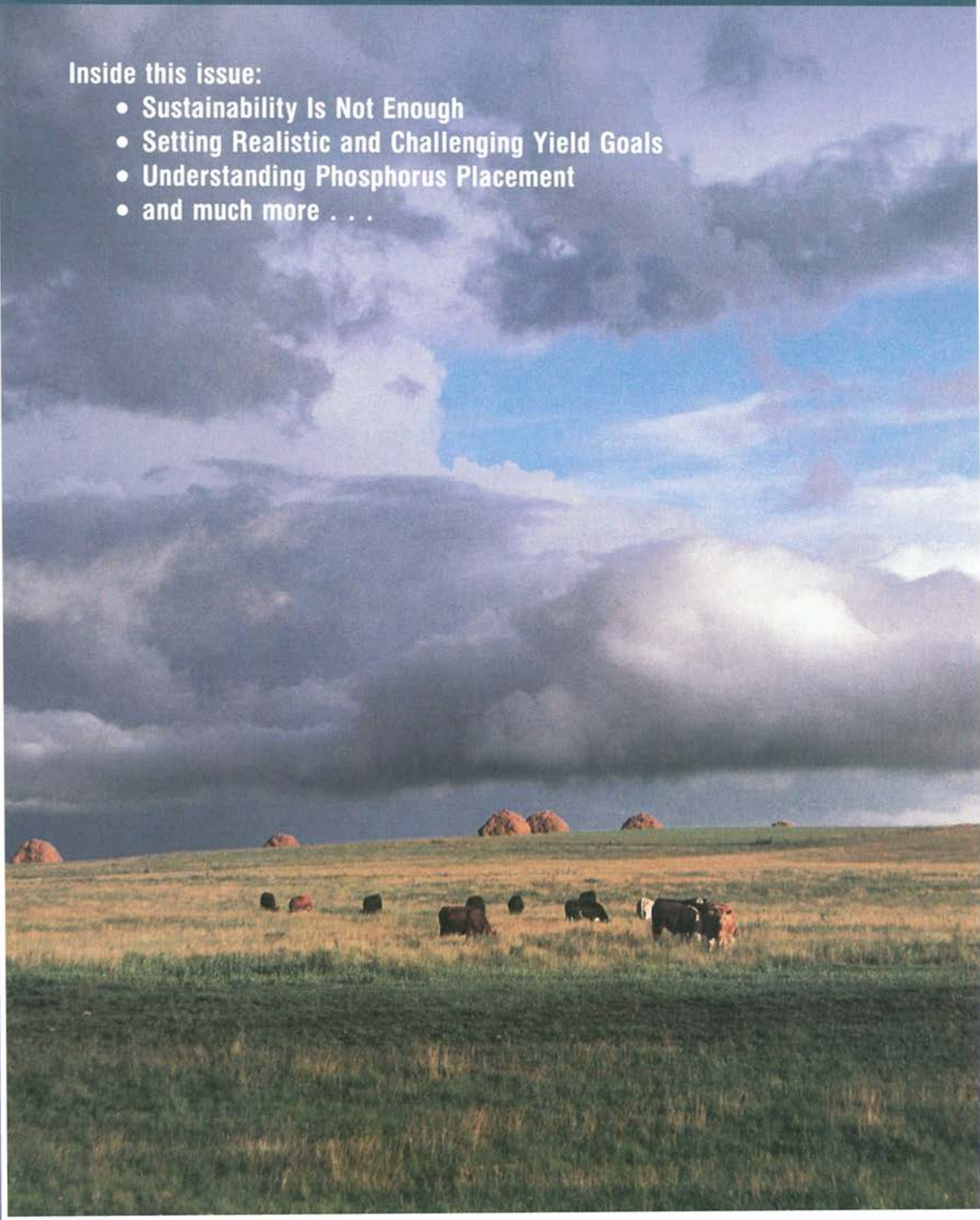

BETTER CROPS With Plant Food

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Our Cover: After the storm, Roberts County, South Dakota.
Photo by Dr. Larry S. Murphy

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Setting Realistic and Challenging Yield Goals

By G.W. Wallingford

Yields are increasing for the major crops in the U.S. This trend started in the 1940s and has continued unabated. While some farmers may be finding it more difficult to afford the necessary inputs, they are continuing to do what it takes to produce higher yields.

THE UPWARD CLIMB of corn yields since 1950 in the U.S. is illustrated in **Figure 1.**

There is no evidence that corn yields are reaching a plateau, although yield variability seems to be increasing.

The 1988 drought cut yields sharply. However, compared to the droughts of the 1930s and 1950s, yields held up remarkably well. Better hybrids, improved fertility, earlier planting, and superior weed control all helped to moderate the yield loss in 1988.

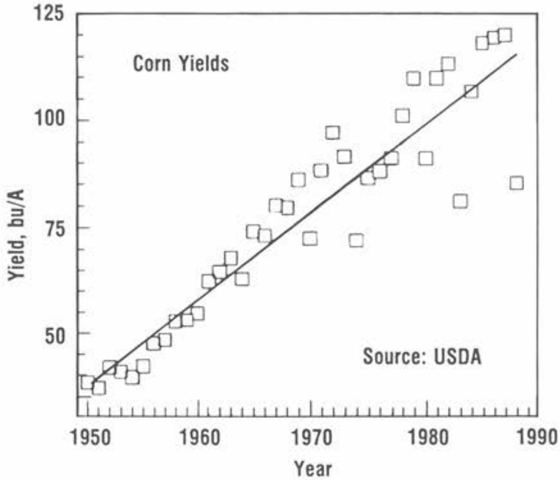

Figure 1. Average U.S. corn yields, 1950-1988.

The trend for U.S. soybean yields is shown in **Figure 2.** While not as rapid as for corn, the increase in soybean yields has been steady. Some obvious and some not-so-obvious points can be made from **Figures 1 and 2.**

- Corn and soybean yields are increasing.
- There is little evidence that yields are leveling off.
- Yields are fluctuating more from good years to bad, but yields in the bad years are still trending upward.
- Growing corn is becoming more competitive as technology and average productivity increase.
- To maintain a competitive advantage, the individual farmer must keep yields increasing at least as rapidly as the average.
- Average yields of almost 120 bu/A are being produced on essentially the same land that produced 50 bu/A yields 35 years ago. **The difference is improved management and inputs.**

The Potential for Higher Yields

How high can yields go? It has been calculated that under average weather conditions in the central Corn Belt, corn yields could reach 490 bu/A and soybean yields 225 bu/A.

(continued on next page)

Dr. Wallingford is Eastcentral Director, Potash & Phosphate Institute (PPI), Suite 290, 2000 W. Henderson, Columbus, OH 43220.

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Herman Warsaw, a farmer near Saybrook, Illinois, grew the world record corn yield of 370 bu/A in 1985. Dr. Roy Flannery of Rutgers University in New Jersey produced 338 bu/A in 1982, the highest corn yield ever produced in replicated research. Dr. Flannery also holds the North American record soybean yield of 118 bu/A.

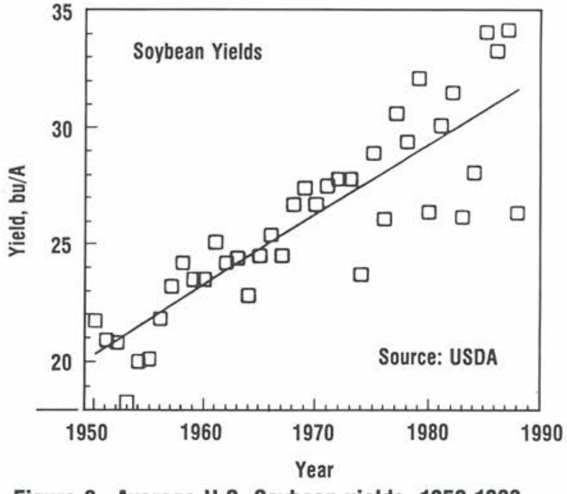

Figure 2. Average U.S. Soybean yields, 1950-1988.

Will Declining Fertilizer Use Hold Yields Down?

One trouble sign on the horizon is evidence that average fertilizer applications rates have reached a plateau and in several cases have begun to fall. While yield trends cannot be predicted by fertilizer use alone, it is a good indicator of how aggressively farmers are pursuing higher yields. Historically, increases in fertilizer use have preceded or paralleled increases in corn yields.

Fertilizer use has leveled off in the U.S. since the late 1970s. In fact, use of phosphorus (P) and potassium (K) has declined, as shown in **Table 1.** Long-term effects, if this trend continues, will be lower crop yields.

Table 1. Fertilizer use per harvested acre in the U.S.

	Annual Rate, lb/A		
Year	N	P_2O_5	K_2O
1978	70	36	39
1982	70	31	36
1987	74	29	35

[1]Not adjusted for non-agricultural use, so actual lb/A on crops is lower.

Set a Yield Goal for Each Field

Different fields on the same farm can have large differences in yield potential. To keep yields moving up, farmers and their advisors must develop separate management plans for each field on the farm. As yield potential increases, small differences in management become more important.

The days of handling all fields the same are past. Besides variations in the soil itself, differences in past fertility and other management require separate plans for each field.

Estimating the Soil's Potential

All information about past management of the field should be gathered. This includes fertility management, pest control, hybrid selection, seeding rate and planting dates. Notes or recall about yield-limiting factors are particularly valuable.

The reasons why yields have varied from year to year should be determined if possible. Comparisons of the variation with other fields on the farm is also helpful. Past yield variation is important because it helps to estimate risk factors.

As much as possible should be learned about the physical and chemical properties of the soil. The county soil survey is an excellent resource. It may not be possible to alter all of these properties, but it is good to start out knowing as much as possible.

Similar soils in the same area that have been managed for high yields should be identified. Valuable insights can come by comparing management practices and yield trends on these soils.

Specific examples of needed background information:

- Past fertilizer and lime management.
- Yield history.
- Past tillage management.
- Soil test results.
- Plant analysis and tissue testing results.
- Soil and drainage classification.
- Weed/insect/pest problems and management.
- ASCS yield rating.
- Soil texture.
- Water holding capacity.
- Compaction problems.

Willingness to Accept Change

If the farmer doesn't want to change, it will be difficult to get him to change. People resist change for various reasons. Some change quickly if they are shown a good reason while others resist change of any kind for no apparent reason.

Farmers who accept change readily are usually the ones who understand the relationship of higher yields and greater profits, know the key factors affecting profit and loss, and know that yield is the most important controllable factor affecting profits.

Some farmers can change their management more quickly than others. Financial constraints, availability of equipment, size of the operation, and organizational abilities all affect how quickly change can be implemented.

Many farmers find it difficult to change management for financial reasons. Using a small field for testing higher yielding practices is a good alternative to use in these situations. Positive results from the test field will help to convince the farmer or his lender of the need to see the improved management on the rest of the farm.

Field Selection

Management on smaller fields can often be changed faster than on larger fields. Using a smaller field size has other advantages.

For example, many farmers are hesitant to try a higher seeding rate for corn because of concern about lodging and greater harvest losses. While a smaller field does not lessen the chance of lodging it does lessen the farmer's exposure to financial loss if serious losses to lodging do occur.

Setting the Yield Goal

It is not easy to set a yield goal for a specific field. Besides the physical limitations of the soil itself, the farmer's management ability and financial situation are major factors. Extensive background information is important but the final decision is largely a judgment call. Judgment improves the more a person works with a farmer and the more experience he has with similar soils.

The yield goal should be realistic yet challenging. It should be low enough to be reachable in three to five years. It should be high enough to require significant changes in management before it can be achieved.

The place to start is with the previous high yield for the field. The new yield goal can be set by increasing the previous high by 10 to 30%, depending on the factors discussed above. A more conservative goal should be taken when dealing with larger acreages; a more aggressive one with smaller acreages. **When the goal is achieved, a new and higher yield mark should be set.■**

New Folder from PPI

LIVESTOCK MANURE —Why It's a Limited Resource for Profitable Crop Production is a new 12-page folder from the Potash & Phosphate Institute (PPI). The publication discusses environmental concerns and limitations of livestock manure as a replacement for commercial fertilizer.

For more information or a complete **Catalog** of information items, contact: Circulation Department, PPI, 2801 Buford Hwy., NE, Atlanta, GA 30329. Phone: (404) 634-4274.■

Sustainability Is Not Enough

By Vernon W. Ruttan

Traditional agricultural systems that met the test of sustainability have not been able to respond adequately to modern rates of growth in demand for agricultural commodities. A meaningful definition of sustainability must include the enhancement of agricultural productivity. At present, the concept of sustainability may be more adequate as a guide to research than to farming practice.

ANY DEFINITION of "sustainability" suitable as a guide to agricultural practice must include **enhancement of productivity** to meet the increased demands created by growing populations and rising incomes. The problems of achieving these goals will be illustrated with some historical examples. The sustainable agricultural movement must define its goals broadly enough to meet the challenge of enhancing productivity and sustainability in both the developed and developing world.

Ambiguity about Technology

The productivity of modern agriculture is the result of a remarkable fusion of science, technology and practice. This fusion did not come easily. The advances in tillage equipment and crop and animal husbandry during the Middle Ages and until well into the 19th century evolved almost entirely from husbandry practice and mechanical insight. The power that the fusion of theoretical and empirical inquiry has given to the advancement of knowledge and technology since the middle of the 19th century has made possible advances in material well-being that could not have been imagined in an earlier age.

These advances have also been interpreted as contributing to the subversion of traditional rural values and institutions and to the degradation of natural environments. They led, in the 1960s and 1970s, to the emergence of a new skepticism about the benefits of advances in science and technology. A view emerged that the potential power created by the fusion of science and technology is dangerous to the modern world and the future of the human race.

This ambiguity about the impact of science and technology on institutions and environments has resulted in a series of efforts to enhance the sensitivity of scientists and science administrators and to reform the decision processes for the allocation of research resources.

These efforts have typically attempted to find rhetorical capsules to serve as a banner under which efforts for reforms might march. Among the more prominent have been "appropriate technology," "integrated pest management," "low-input technology", and more recently, "sustainability."

Dr. Ruttan is Regents Professor, Department of Agricultural and Applied Economics and Department of Economics and Adjunct Professor, Hubert H. Humphrey Institute of Public Affairs, University of Minnesota, St. Paul.

This article is adapted from a paper originally presented at the Symposium on Creating a Sustainable Agriculture for the Future, University of Minnesota, April 1988. A list of references is available on request.

". . . the commitment to support the development of the research capacity in both developed and developing countries that will be necessary to achieve productive and sustainable agricultural systems has been weakening. And I am also concerned that the sustainability movement is pressing for adoption of agricultural practices under the banner of sustainability before either the science has been done or the technology is available."

Reforming Agricultural Research

It is not unusual for such rhetorical capsules to achieve the status of an ideology or a social movement while still in search of a methodology, a technology, or even a definition. If the reform movement is successful in guiding scientific and technical effort in a productive direction, it becomes incorporated into normal scientific or technological practice. If it leads to a dead-end it slips into the underworld of science often to be resurrected when the conditions which generated the concern again emerge toward the top of the social agenda.

Research on new uses for agricultural products is an example. It was promoted, in the 1930s under the rubric of chemurgy and in the 1950s, under the rubric of utilization research as a solution to the problem of agricultural surpluses. It lost both scientific and political credibility because it promised more than it could deliver. It has emerged again, in the late 1970s and early 1980s, in the guise of enhancing the **value added.**

The **"sustainability"** movement, like other efforts to reform agricultural research, has experienced some difficulty in arriving at a definition that can command consistency among the diverse and sometimes incommensurable reform movements that are marching under its banner. Fortunately we can draw on several historical examples of sustainable agricultural systems.

Sustainable Agricultural Systems

One example was the system of integrated crop-animal husbandry that emerged in Western Europe in the late

Middle Ages to replace the medieval two and three field systems. The "new husbandry" system emerged with the introduction and intensive use of new forage and green manure crops. These in turn permitted an increase in the availability and use of animal manures. This permitted the emergence of intensive crop-livestock systems of production through the recycling of plant nutrients in the form of animal manures to maintain and enhance soil fertility.

A second example can be drawn from the agricultural history of East Asian wet rice cultivation. Traditional wet rice cultivation resembled farming in an aquarium. The rice grew tall and rank; it had a

low grain-to-straw ratio. Most of what was produced, straw and grain, was recycled into the flooded fields in the form of human and animal manures. Mineral nutrients and organic matter were carried in

(continued on next page)

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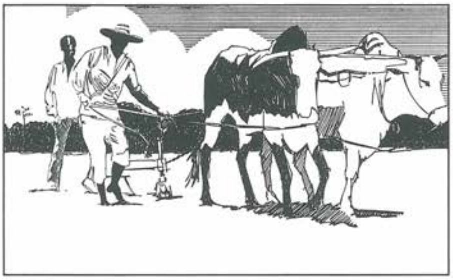
and deposited in the fields with the irrigation water. Rice yields rose continuously, though slowly, even under a monoculture system.

A third example is the forest and bush fallow (or shifting cultivation) systems practiced in most areas of the world in pre-modern times and today in many



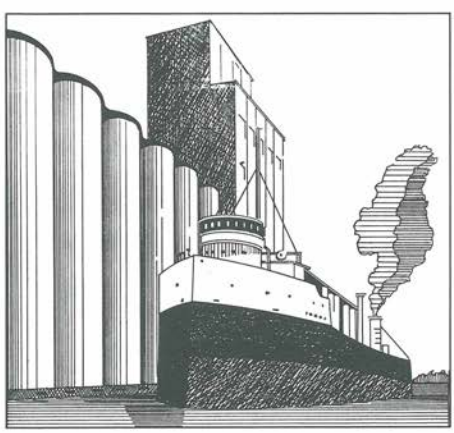
areas of tropical Africa. At low levels of population density these systems were sustainable over long periods of time. As population density increased, short fallow systems emerged. Where the shift to short fallow systems occurred slowly, as in Western Europe and East Asia, systems of farming that permitted sustained growth in agricultural production emerged. Where the transition to short fallow has been forced by rapid population growth the consequence has often been soil degradation and declining productivity.

Sustaining and Enhancing Productivity

This brings me to the title of this paper. The three systems described above, along with other similar systems based on indigenous technology, have provided an inspiration for the emerging field of agroecology. But none of the traditional systems, while sustainable under conditions of slow growth in demand, has the capacity to respond to modern rates of growth in demand generated by some combination of rapid population and/or rapid income growth. Some traditional systems were able to sustain rates of growth in the range of 0.5 to 1.0 percent annually. But modern rates of growth in demand run in the 1.0 to 2.0 percent per year range in the developed countries. They often run 3.0 to 5.0 percent per year in the less developed and newly industrializing countries. Rates of growth in demand in this range lie outside of the historical experience of the presently developed countries!

In searching the literature on sustainability I do not find sufficient recognition of the challenge that modern rates of growth in demand imposes on agriculture. **If the concept of sustainability is to serve as a guide to practice it must include the use of technology and practices that both enhance and sustain productivity.**

In the United States the capacity to sustain the necessary increases in agricultural production will largely depend on our capacity for institutional innovation. If we lose our capacity to sustain growth in agricultural production it will be a result of political and economic failure. Failure to reform agricultural commodity programs in a manner that will contribute to both sustaining and enhancing productivity will mean the loss of one of the few industries in the United States that has managed to retain world-class status—that is capable of competing in world markets.



In contrast it is quite clear that the scientific and technical knowledge is not yet available that will enable farmers in most tropical countries to meet the current demand their societies are placing upon them or to sustain the increases that are currently being achieved. Nor has the research capacity that will be necessary to provide the knowledge and the technology yet been established. In these countries achievement of sustainable agricultural surpluses is dependent on advances in scientific knowledge and on technical and institutional innovation.

Implications for Research

I am deeply concerned that the commitment to support the development of the research capacity in both developed and developing countries that will be necessary to achieve productive and sustainable agricultural systems has been weakening. And I am also concerned that the sustainability movement is pressing for adoption of agricultural practices under the banner of sustainability before either the science has been done or the technology is available.

It has been surprisingly difficult to find careful definitions of the term sustainability. This is at least in part because if "sustainability" is to provide a useful rhetoric for reform it must be able to accommodate the several traditions that must march under its banner. These include the organic agriculture tradition, the land stewardship movement, the agroecology perspective and others. In my judgment any attempt to specify the technology and practices that meet the criteria of enhancing and sustaining productivity would be premature.

At present it is useful to define sustainability in a manner that will be useful as a guide to research rather than as an immediate guide to practice.

As a guide to research it seems useful to use a definition that would include (a) the development of technology and practices that maintain and/or enhance the quality of land and water resources, and (b) the improvement in plants and animals and the advances in production practices that will facilitate the substitution of biological technology for chemical technology.

Furthermore, it is desirable to generate the knowledge that will enable us to determine what it is possible to achieve in the direction of the above objectives primarily from a biological perspective. **Maximum yield experiments represent a useful analogy. The objective of a maximum yield experiment or trial is not to provide a guide to farm practice.** Rather it is to find out how a plant population performs under high level input stress.

The research agenda on sustainable agriculture needs to define what is biologically feasible without being excessively limited by present economic constraints.■

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Optimizing Rice Yields by Integrating Management Practices

By B.R. Wells, R.J. Norman, K.A.K. Moldenhauer and F.N. Lee

Lemont and Newbonnet rice cultivars produced similar yields in a two-year Arkansas study, with an overall trend toward higher yields by Lemont. At one location, potassium (K) fertilization gave a response in both years. Nitrogen (N) rates above 120 lb/A produced small yield increases in some cases, but reductions in other situations. Use of a foliar fungicide resulted in higher yields at two locations both years.

THE PROFIT MARGIN for rice production in recent years has been very narrow. Thus, farmers are forced to look carefully at inputs and choose only those with a high probability of increasing yields sufficiently to more than offset their cost. At the same time, the introduction of new, high-yielding cultivars, new herbicides, and increased disease incidence led to more difficulties in making decisions which would lead to greater profitability.

Our field studies in 1985 and 1986 evaluated the influence of an integrated fertility-fungicide management system on yields of two high-yielding rice cultivars being grown on typical rice soils in Arkansas. The studies were conducted at three sites: the University of Arkansas Rice Research and Extension Center (RREC) at Stuttgart, on a Crowley silt loam; the Pine Tree Station (PTS) at Colt, on a Calloway silt loam; the Northeast Research and Extension Center (NEREC) at Keiser, on a Sharkey clay.

Two new rice cultivars, 'Newbonnet' and 'Lemont,' were grown at varying levels of nitrogen (N), phosphorus (P), potassium (K) and with and without use of a foliar fungicide (benomyl). Grain yields were taken at maturity and used as the criteria for response to treatments.

Soil test levels of P and K for the soils used in the studies are given in **Table 1.** Based on current recommendations for rice growing on these soils in Arkansas, no P fertilizer would have been recommended at any of the locations; K fertilization would have been recommended only on the Calloway silt loam at PTS.

Table 1. Soil test levels of P and K for the test sites.

Location Year	Nutrient Level P[1]	Nutrient Level K[2]
	------lb/A------	
RREC-1985	16	150
1986	14	170
PTS-1985	18	110
1986	17	100
NEREC-1985	85	670

[1]Phosphorus - Bray P-1
[2]Potassium - Neutral Normal Ammonium Acetate

RREC - Rice Research and Extension Center
PTS - Pine Tree Station
NEREC - Northeast Research and Extension Center

Rice in all studies was grown under relatively weed-free conditions and with a continuous flood maintained from the five-leaf stage of rice plant development until approximately two weeks prior to harvest. These are conditions attainable in commercial rice fields and are necessary to maximize cultivar response to the treatments.

Grain yields ranging from 6,500 to 9,000 lb/A (144 to 200 bu/A) were achieved in the study. Both cultivars produced similar yields, however, there was an overall trend for the Lemont to produce slightly higher yields. Newbonnet is a short-statured, up-

B.R. Wells is Professor of Agronomy, University of Arkansas. R.J. Norman and K.A.K. Moldenhauer are Associate Professors, and F.N. Lee is Professor, University of Arkansas Rice Research and Extension Center.

right leaf conventional cultivar while Lemont is a semidwarf. When grown under high fertility conditions, Newbonnet plants are approximately 12 inches taller at maturity than Lemont. The level of N fertility will have a major impact on the plant height of Newbonnet, but only a small effect on height of Lemont. These results indicate, in spite of the plant type differences, the two cultivars are capable of similar grain yields under optimum management conditions.

Nitrogen

As is the case for most grain crops, N is the element most limiting for rice production. This demand plus the larger N losses associated with the aquatic environment of a rice field results in the need to apply relatively large amounts of N fertilizer to most rice soils. In these studies response of the rice to N fertilization varied with location (soil) and year. However, in most instances there were either small positive yield responses or relatively large negative yield responses to N rates of either 180 or 240 lb/A as compared to the 120 lb/A rate of N. There were cultivar x N rate interactions for grain yield at PTS in 1985 and at RREC in 1986. In these instances the 240 lb N/A application reduced yields on Newbonnet comparatively more than for Lemont. This would be expected since earlier studies have shown Lemont to require more N fertilizer to maximize yields and to be more tolerant of excessive N rates.

P and K

Normally, P availability to plants increases following flooding of the soil for rice. Therefore, for most soils in Arkansas there is no response of rice to direct applications of P, especially if the other upland crops in the rotation are fertilized with P. A soil test level of 10 lb/A or above (Bray P-1) or fertilization of the previous crop with P are situations where adequate P should be available to maximize rice yields. Based on these criteria rice would not have been expected to respond to P fertilization at any of the sites. No response was noted.

The rice growing on the Calloway silt loam at the PTS showed a response to K fertilization **(Table 2).** Soil test levels of K at this site **(Table 1)** were below the levels that we consider necessary to maximize yields. There was no rice response to K fertilization on either the Crowley silt loam (RREC) or the Sharkey clay (NEREC) where the soil test levels for K were above the levels we consider necessary to maximize yields. These data indicate that the current critical soil test levels for K are approximately those necessary to optimize grain yields of rice.

Table 2. Grain yields of rice as influenced by K fertilization, location and year.

K_2O	1985			1986	
Rate	RREC	PTS	NEREC	RREC	PTS
lb/A	-----lb/A-----				
0	8,769	6,799	8,050	7,576	6,989
50	8,908	7,087	8,167	7,681	7,742

Two rice diseases, sheath blight and blast, were observed in the studies. Sheath blight occurred at all locations in both years of the study, however, the level of infestation was lowest at the NEREC location. Blast was observed at the Pine Tree mainly on Newbonnet. Application of the foliar fungicide (benomyl) resulted in higher grain yields at RREC and PTS for both years of the study **(Table 3).** This yield increase was accompanied by visual observations of lower disease infestations, especially sheath blight.

Table 3. Grain yields of rice as influenced by fungicide (benomyl) application, location and year.

Fungicide	1985			1986	
applied	RREC	PTS	NEREC	RREC	PTS
No	8,516	6,724	8,118	7,576	6,989
Yes	9,161	7,162	8,099	8,062	7,445

Results from this research support the philosophy that consistently high rice yields can be obtained utilizing a management program based on soil tests and overall recommendations specific for the cultivars being grown under the conditions prevailing in Arkansas rice fields. Success with the program indicates that proper attention to management details, rather than extra inputs, is the key to optimizing rice yields.■

Acknowledgement: This research was supported in part by a grant from the Foundation for Agronomic Research (FAR).

A Worthy Legacy from a Worthy Leader: Dr. R.E. Wagner

By Santford W. Martin

R.E. Wagner

Note: Bob Wagner stepped down as President of the Potash & Phosphate Institute (PPI) at the end of 1988. I had occasion to visit him several weeks later and, during the course of the conversation, asked how things were going. I was struck by his enthusiastic response. How he is upgrading his herd of purebred cattle. How he is adding a new breed to his operation.

In some ways, Bob Wagner didn't retire last December. He simply laid aside a task he had completed and moved on to another challenge.

The following article is a summary of reflections of a PPI editor who also recently retired. He worked closely with Dr. Wagner and other PPI Presidents through the years. The picture the author paints for you might seem to have a "rosy" tint. All of us in the Institute readily admit our bias when it comes to Bob . . . but his record speaks for itself. He was and is a true leader. We thought our readers would enjoy this insight.

—Dr. B.C. Darst, Vice President, PPI

VALUES. We hear a lot about values today.

Every time I think of values I think of the six bosses I had across a 40-year career of teaching, editing, and writing.

All six lived by exceptionally high values: President Phil Elliot of Gardner-Webb College; Chancellors John Harrelson and Carey Bostian of North Carolina State University; and Presidents Harvey Mann, J. Fielding Reed, and Robert E. Wagner of the Potash & Phosphate Institute and its forerunners.

As a working journalist, it fell my privilege to say a few words to and about these leaders as they retired. And now, at the retirement season of Institute President Wagner, I am honored to express a view on my last boss in my 40-year journey to this happy retirement rocker from which I write.

For almost three decades I considered it a great privilege to work for the fertilizer industry, even in a minor capacity, because of its vital role in the survival of mankind on this wonderful planet.

I heard Dr. Wagner once express the same sentiment. But in his case, it can be added that Bob Wagner's leadership of the Institute brought far more honor to the industry than the industry could ever bring to him.

Mr. Martin served as Editor at the Potash & Phosphate Institute for nearly 30 years until his retirement in 1987.

And that's the way it should be, because that's the way it was with Institute Presidents Reed, Mann, and Turrentine —leaders, like Dr. Wagner. Their tenacious and courageous loyalty to scientific truth gave industry a special stature and integrity so that it could carry on its mission of helping the farmer feed the world.

Values

Once, after describing Dr. Wagner's leadership of Maryland's Cooperative Extension Service as "efficient, industrious, fair, effective, and full of integrity," University of Maryland President W.H. Elkins concluded:

"Bob Wagner's values are those we all ought to live by."

Legions of people applaud that, including, **especially including,** I'm sure, the Board of Directors and the Staff of the Potash & Phosphate Institute.

Not because of the Distinguished Service Award Kansas State University presented Bob Wagner "for outstanding services to agriculture" or the Distinguished Citizenship Award the State of Maryland extended him.

Not because of his invitations into such directories as Who's Who in America, American Men of Science, Who's Who in the East and South, or Men of Achievement.

WELL KNOWN for his success in building agronomic understanding around the world, Dr. Wagner is shown with Prof. Xie Jianchang (left) of the Nanjing Institute of Soil Science during an international conference in 1986.

Not because he served on the American Society of Agronomy Board of Directors or helped lead four International Grassland Congresses in America, England, New Zealand, and Brazil. Not because of his gubernatorial appointments to special farm commissions or his services on the advisory bodies of the Southern Regional Education Board and the National Association of State Universities and Land-Grant Colleges, helping guide graduate education, agricultural research, and rural development in changing times.

Not because the American Society of Agronomy and the American Association for the Advancement of Science named him a Fellow, the highest award these prestigious bodies bestow.

Not because the American Forage and Grassland Council gave special recognition to his "outstanding services to grassland farming" or because the major fraternities of Alpha Zeta, Gamma Sigma Delta, Phi Kappa Phi, and Sigma Xi sought his membership.

Not because he served on the Steering Committee of the Fertilizer Industry Advisory Committee for the United Nations Food and Agricultural Organization (FAO) in Rome.

Not because he served on the TVA-NFDC Executive Industry Review Group or the IFDC Board and Executive Committee.

Not because of the countless crop rows he walked and studied with farmers and fertilizer dealers and official agriculturists of all kinds in many parts of the world.

Not because he chaired a major university Agronomy Department at a very early age or directed a major State Extension Service or served as president of a unique research and education Institute.

Not because he led in creating the Foundation for Agronomic Research

(continued on next page)

R.E. Wagner . . . from page 13

(FAR) or the concept of maximum economic yield (MEY), an agronomic-economic philosophy now growing around the world.

Not for the superb leadership Bob Wagner gave to agriculture and the fertilizer industry. Why not? Because all his leadership talents pale in the presence of an observation Dr. J. Fielding Reed once made when he said, "Bob Wagner is the very essence of goodness."

Spirit

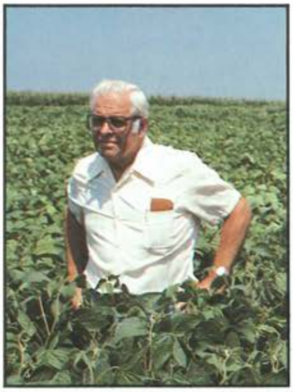
That is the root of his influence, the secret of his success across more than 40 years of innovative ideas and progress–his spirit of human goodness.

A spirit that never sacrificed scientific integrity on the altar of political expediency, that constantly searched for ways to put more science and less politics into solving –and perhaps dissolving–the Farm Problem.

A spirit that reflected in down times the most powerful energy on earth–**human hope**–a force that science cannot define and time cannot destroy.

A spirit that quietly fed his abundant administrative, teaching, research, speaking, and writing talents.

A spirit that always walked the high road, that never dealt in petty, negative judgments of fellow leaders, that never met snide comments with anything but wholesome, positive facts on the issues of the day.



THE INNOVATION of maximum economic yield (MEY) systems began with Dr. Wagner's leadership.

There is a photo I will never forget. It shows a group of small Chinese children looking up at Dr. Wagner with innocent wonder written across their faces and Dr. Wagner smiling down warmly at them.

It is clear that on this scientific trip to China, this distinguished American agronomist is greeting these children with the very same dignity and kindness he would greet the highest corporate leader.

Why?

Because Bob Wagner is one of God Almighty's gentlemen on this earth. The fertilizer industry was blessed to have him–and I was blessed to work for him.

Press on.■

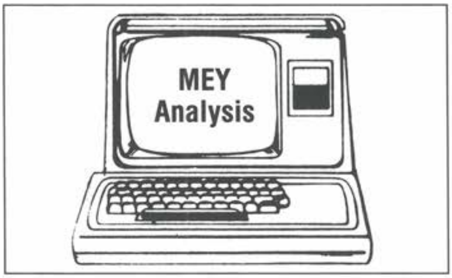
DURING AN EARLY trip to China, Dr. Wagner captured the attention of this group of young people.

"MEY Analysis" Software as a Teaching Tool

By Brian S. Baldwin and Kenneth J. Moore

Since it was introduced in 1985, the "MEY Analysis" software package from the Potash & Phosphate Institute (PPI) has been used in numerous workshop programs for growers, dealers, agronomists, consultants, university specialists, and others. This article highlights the experience of university students in a crop production class.

FINANCIAL MANAGEMENT is one of the most complex and challenging problems facing agricultural producers. Many producers are unable or are unwilling to analyze their production practices to determine which input costs can be minimized and which should be increased to achieve optimum production.



In an attempt to expose future producers to the advantages of using a computer in making farm management decisions, the Crop Production class at New Mexico State University was assigned a project using the "MEY Analysis" computer program.

The class was divided into farming groups consisting of two or three people and each group was assigned a farm scenario. The scenarios were representative of actual farming systems practiced in a number of counties in New Mexico and varied in the crops grown, methods and cost of irrigation, soil type, and climate.

Each student developed a detailed production plan for a crop grown on the sample farm, using whatever information sources were available. The plans included information on soil management, crop establishment, water management, pest management, and harvesting. The students used extension publications, contacted seed and fertilizer distributors, and consulted with specialists for the information necessary to develop their individual plans. Each farm group then entered the information from the individual crop plans into the Multiple Field Plan worksheet in order to generate a farm summary.

Having students develop a crop plan is a common exercise in crop production courses. The unique aspect of this assignment using "MEY Analysis" was that the students were required to take into account the economic consequences of their decisions. For example, they learned that in areas of the state where irrigation water is expensive, good decisions with respect to water management made the difference between profit and loss. In other areas of the state where irrigation water is cheap and abundant, fine-tuning their fertilizer program became critical to optimizing profitability.

Use of the "MEY Analysis" computer program helped the students of our Crop Production class appreciate the complex management decisions required to produce a crop. As a consequence, they are now better prepared to deal with the economic realities of farming.■

Mr. Baldwin is a graduate teaching assistant, Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, New Mexico. Dr. Moore, formerly Associate Professor at New Mexico State, is now with the USDA/ARS, Department of Agronomy, University of Nebraska, Lincoln, Nebraska.

Nutrient Levels in Plant Tissue Indicate Optimum Potash Rates for Coastal Bermudagrass

By Marcus M. Eichhorn, Jr. and William B. Hallmark

Louisiana research is answering questions on potash (K) fertilization rates, application frequency, concentration levels in forage, exchangeable levels in soil, and other relationships in Coastal bermudagrass production.

FOR THE PAST 30 years, research on fertilizer requirements of Coastal bermudagrass for hay production has left many questions unresolved relative to K fertilization.

For example:

- What are the effects of K_2O rates and application frequency on forage yield per cutting and on K tissue concentration in harvested forage?
- What are the K tissue concentrations in forage which will confirm deficient, critical, adequate, and high levels of K nutrition?
- What is the relationship between K concentration in forage and forage yield?
- What is the relationship between K concentration in forage and soil exchangeable K level?

A five-year K fertilization study was conducted to seek answers to these questions. An existing planting of Coastal bermudagrass on Mahan fine sandy loam soil was chosen for the experimental site. Hay yield at initiation of the study was 60% of yield potential. Exchangeable soil K was at a very low level after 11 years of hay cropping.

For five years, K_2O was applied annually by various methods at rates up to 600 lb/A. Single application made by April 1; a two-way split (half by April 1 and half after the second cutting) and in a four-way split (one-fourth by April 1 and one-fourth after the first, second, and third cuttings). Nitrogen (N), phosphate (P_2O_5), sulphur (S) and boron (B) were also applied annually at 400(100/cut)-150-90-2 lb/A. In addition to fertilizer, dolomitic limestone was applied at 2 tons/A prior to initiation of fertilization practices and at one ton/A after three years of fertilization and cropping.

Forage yields and tissue concentrations of K, N, phosphorus (P), calcium (Ca), and magnesium (Mg) were determined from forage harvested in early-seedhead development. Four cuttings were made annually except for one year in which the fourth cutting was eliminated because of drought. Exchangeable soil K was determined after five years of K fertilization and cropping.

Yield responses of Coastal bermudagrass to K_2O fertilization, averaged over five years, ranged from 843 lb/A each year at the 100 lb/A K_2O rate to 1,443 lb/A at the 600 lb/A rate. Responses to K fertilization were observed at each cutting. Application

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Table 1. Mean effects of K fertilization on forage yields and nutrient concentrations in harvested forage of Coastal bermudagrass, 1980-84.

Annual K_2O Rate	Forage Yield	Nutrient concentration				
		K	N	P	Ca	Mg
lb/A	lb/A	%				
0	2,324	0.77	2.41	.23	.40	.23
100	3,167	1.17	2.27	.22	.38	.22
200	3,499	1.46	2.21	.21	.38	.21
400	3,717	2.00	2.22	.20	.38	.18
600	3,767	2.24	2.20	.20	.38	.17
	**	**	**	**	ns	**

ns F value not significant at 5% level of probability level of probability.
** F value significant at 1% level of probability.

frequency did not affect yields. Optimum forage yield per cutting (at least 95% of maximum) was produced at the 400 lb/A K_2O rate.

Forage Yield and Nutrient Concentration

Concentrations of K, N, P, and Mg in forage, were influenced by K fertilization, **Table 1.**

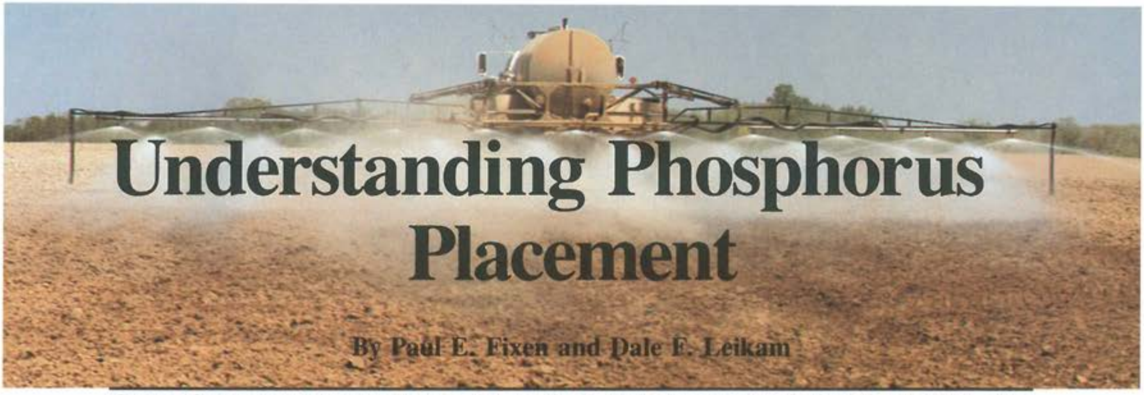
Results showed that forage yield per cutting declined when concentrations of K were less than 2.24% and concentrations of N, P, and Mg were greater than 2.20, .20, and .17%, respectively. Mean Ca tissue concentration range of .38 to .40% had no effect on forage yields.

Summary

Optimum forage yield of Coastal bermudagrass on K deficient Coastal Plain soil was produced where 400 lb/A of K_2O was applied annually for 5 years in the presence of 400-150-90-2-lb/A of N-P_2O_5-S-B. Yield response per cutting was 13.9 lb/A/lb of applied K_2O/A. Potassium concentrations in forage over all cuttings and years ranged from .77% at 0 lb/A of K_2O to 2.24% at 600 lb/A of annually applied K_2O over all application frequencies. Irrespective of applied K_2O rate, K concentration was highest in forage where two applications of K were made in equal increments. K concentration in forage at optimum forage yield ranged from 1.71 to 2.58% and averaged 2.00%.

Regression and DRIS analysis data revealed that concentrations of K in Coastal bermudagrass at hay growth development was: (1) deficient where K was less than or equal 1.10%; (2) critical where K ranges from 1.11 to 2.00%; (3) adequate where K ranged from 2.01 to 2.24% and (4) high where K was above 2.24%. Application of 100 lb/A of K_2O/cutting was required to maintain K in forage at adequate level of K nutrition. Where K nutrition was high, maximum forage production occurred where mean concentrations of N, P, Ca, and Mg were above 1.30, .12, .13, and .08%, respectively.

Soil data predicted that adequate K nutrition was present for the production of Coastal bermudagrass when exchangeable soil K at 0- to 12-inch depth was 95 ppm.■



Understanding Phosphorus Placement

By Paul E. Fixen and Dale F. Leikam

Contradictory recommendations for method and placement of phosphorus (P) often are due to the fact that conditions influencing P fertilizer response vary among studies. This review helps to clarify some results on crop response to P placement.

WHICH IS BETTER, band or broadcast P applications? Are all band P application methods equal in effectiveness? How much can P recommendations be reduced if P is banded instead of broadcast? Questions on the merits of various P application methods are fueled by research results which often point in different directions.

Factors Influencing P Response

Several factors influence fertilizer P response, including:

- Soil test levels;
- Root contact with the fertilized soil;
- P concentration of the fertilized soil solution.

Soil Test Level

As the surface soil P test level increases, the relative portion of plant P uptake derived from P fertilizer decreases. At high soil test levels, the addition of fertilizer has little effect on P uptake. This seems simple enough, but the soil test level at which there is no response to fertilizer P varies from soil to soil **and** from year to year. It is safe to say, however, that the **probability** of response decreases as soil test level increases.

Fluctuations in the release of P from organic matter may be responsible for part of this response variability. Subsoil P levels can influence fertilizer P response if sufficient subsoil root development occurs. Total root length and distribution relative to shoot growth is likely one of the important factors influencing the soil test P level requirement for optimum growth as well as the response to applied P fertilizer. A plant with an abundance of roots relative to shoots will require a considerably lower P soil test level for optimal growth than if root development is limited. Root development will be discussed in more detail later.

Root Contact with the Fertilized Soil

No factor influencing plant response to P fertilizer placement is more important than the degree of root contact with the fertilized soil. Total root length/activity, the volume of soil fertilized, and location of the fertilized soil are major considerations relative to root contact.

Total root length. Total root length generally increases as yield increases, but a multitude of factors influences the magnitude of the increase. Studies on several crops have shown that shoot growth is increased more than root growth as available water increases. Conditions that encourage extensive root growth relative to shoot growth may produce very little P response, even on low testing soils, since the plant is able to obtain adequate P from the unfertilized soil.

Low soil temperature and excessively wet soils decrease both total root length and root metabolic activity and can be a major factor in P response, even at high P soil test levels. Root disease, insect damage, soil compaction, variety and

Dr. Fixen is Northcentral Director of the Potash & Phosphate Institute (PPI), and is located in Brookings, South Dakota. Dr. Leikam is Agronomist, Farmland Industries, Kansas City, Missouri.

ammonium levels in the soil are some of the factors that influence root length and activity. Mycorrhizae (a beneficial root fungus) infection can increase effective root length and activity and improve plants' ability to extract soil P.

Volume of soil fertilized. Volume of soil fertilized influences the degree of root contact with the added nutrients. If a broadcast fertilizer-moldboard plow application affects 100 percent of the soil, a band application on 30-inch spacing fertilizes only about one percent of the soil volume. Even though only one percent of the soil volume may be fertilized in a typical starter band, more than one percent of the root system is affected due to a proliferation of roots in the band. Studies have shown that a band influencing one percent of the soil may contain approximately 4 percent of the root system, still leaving 96 percent of the root system unaffected by the applied P fertilizer. From strictly a root contact standpoint, this is not desirable. The presence of ammoniacal nitrogen (N) in the P band has been shown to further increase root proliferation and enhance P uptake.

In reduced tillage systems where P bands are not disturbed by subsequent tillage, residual effects of P fertilization may be significant. Over time, the volume of soil affected by P banding results in a greater portion of the root system contacting soil affected by P fertilizer. In cases where the residual bands are destroyed by tillage, residual effects would be similar to those of broadcast applications.

Recently, Nebraska researchers have shown that pumps used in banding fluid P sources may affect P use efficiency. When pumps deliver a series of droplets rather than continuous bands, P use efficiency may be detrimentally affected. The small volume of soil affected by those droplets may limit root contact and P uptake. Rate of application, speed of the application equipment, size of the delivery tube and spacing between points of application all could affect P use efficiency from bands.

Location of the fertilized soil. Location of the fertilized soil also affects root contact with the applied nutrients. Fertilizer P is relatively immobile in soils and the objective of placement is to put nutrients where roots are most concentrated and active. South Dakota research provides a good example of where this objective was not accomplished. **(Figure 1).**

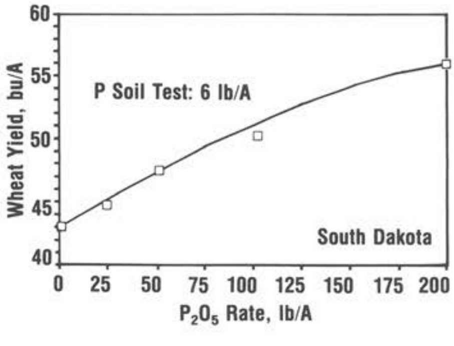


Figure 1. Wheat yields with various rates of P broadcast, shallow incorporation before seeding.

When P was broadcast and only shallowly incorporated with sweeps prior to seeding, wheat yields were still increasing at the highest rate of application, 200 lb/A P_2O_5. Fertilizer P use efficiency had obviously been lowered by this shallow application. Detailed soil sampling indicated that minimal incorporation had influenced soil solution P concentrations in only the top two inches of soil. Root activity in that zone is limited in the hot, dry environment of central South Dakota resulting in fertilizer P being positionally unavailable and inefficient.

In addition to soil moisture, soil temperature, distance of fertilizer band from the seed, soil compaction and other factors influencing root activity affect the optimum location of fertilized soil. Severe stratification of P and resulting poor performance of broadcast P applications are likely common in much of the wheat/fallow region of the Great Plains.

Phosphorus Level of the Fertilized Soil

Basically, the relationship between fertilizer P and the concentration of P in the soil solution is represented by line A in **Figure 2.** Low rates of applied P have only a minor impact on usable P in the soil solution because the fertilizer P is reacting with soil components which

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Phosphorus . . . from page 19

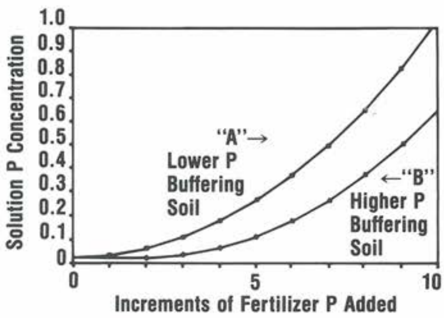

Figure 2. Relationship between fertilizer P and concentration of P in the soil solution. Higher rates are needed for soils that have higher capacity to react with fertilizer P.

make it less available. As the application rate increases, more and more P remains in soil solution where it can have an immediate effect on plant uptake.

Substantially higher rates of fertilizer P are required to increase soil P availability in soils that have a high capacity to react with fertilizer P **(line B, Figure 2).** Low soil test P levels, high clay contents, high contents of calcium carbonate, and elevated iron or aluminum oxide contents tend to make soils more reactive with fertilizer P.

If only the soil's ability to react with P was considered, fertilizer should be mixed with as little soil as possible. That would result in a minimum amount of detrimental P reactions and a maximum amount of P in soil solution. However, higher concentrations of P in soil solution improve plant uptake only to a point **(Figure 3).**

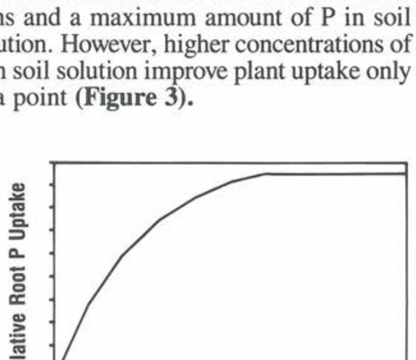

Figure 3. Potential plant root uptake of P increases rapidly with higher solution P concentration in soil water, but gradually approaches a maximum.

Uptake initially increases rapidly with increasing solution P concentrations in the soil water, but gradually approaches a maximum rate of uptake. If banded fertilizer increases the P concentration beyond that which the roots can utilize, P uptake will plateau and P use efficiency will decline.

Consequently, the best placement for a given soil situation will be the one providing an optimum balance between minimizing detrimental fertilizer reactions with the soils and maximizing contact with roots. Considering the number of factors influencing this balance, it is not surprising that P placement studies don't always yield the same results and that placement recommendations are debated.

Common Application Methods

A number of P application alternatives exist. The major types are listed in **Table 1** along with an estimate of the soil volume affected by each.

Incorporation depth and placement method of surface applications affect the volume of soil fertilized and its location. For band placements, spacing and location relative to plant rows can affect percentage of soil fertilized and P use efficiency.

Table 1. Effect of P application method on the proportion of a six-inch soil volume fertilized.

Placement Method	Inc. Depth	Theoretical Soil Portion Fertilized
	Inches	%
Surface Applications		
Broadcast/Inc.	6	100
Broadcast/Minimal Inc.	2	33
Broadcast/Unincorp.	0.4	7
Preplant Surface Band[1]	0-6	1-100
Band Applications		
Drill Row (Seed Contact)	Band Spacing[2]	
Preplant Dual/ Deep Band	6	1.9
Band Near Seed	15	1.5
Dribble Over Seed	30	1.1

[1] Bands estimated at 25 lb P_2O_5/A 20 days after application on a Poinsett silty clay soil; percentages would increase as rate increases.

[2] Soil portion fertilized depends on spacing and incorporation depth.

Narrowing band spacings at a constant P rate increases the volume of the soil affected, but not proportionally because P is applied in decreasing individual band diameters. The affected soil volumes in **Table 1** are estimates calculated from studies of P movement.

Considering the factors discussed earlier, it has been estimated that on soils likely to produce a P response, the optimum fertilized soil volume for a rate of 50 lb/A P_2O_5 varies from one to 20 percent.

Band vs. Broadcast Comparisons

Discussion of P placement decisions usually simplifies to two basic questions: (1) Do I band or broadcast? and (2) If I band, what rate adjustments are possible? There are no universal answers to these questions since the relative effectiveness of band or broadcast applications vary depending on the specific situation. At least four relationships between band and broadcast applications have been demonstrated by research in the Great Plains. These are described in the following, Situations A, B, C and D.

Situation A: Broadcast equals band.

This situation has been observed where soil test levels are relatively high and P fixation is limited. Thorough incorporation of P results in good root contact and increases the probability of the fertilizer being located in moist soil. Warm season crops such as grain sorghum, soybeans, sunflowers and, to a lesser extent, corn are more likely to exhibit this type of response.

Situation B: Band yields exceed broadcast yield at low rates, equal at high rates.

This response has been verified in numerous studies and would be associated with low soil test levels, high P fixing soils and cold, wet soil conditions. Research producing responses of this type is the basis for recommendations that P application rate be reduced if P fertilizer is band-applied rather than broadcast.

Situation C: Broadcast never equals band.

At least two sets of circumstances can lead to this type of response. One example is a cold, wet soil leading to large early growth response to banded P. This is important when accelerated early growth rate is critical in achieving a growing season's full potential.

The second set of circumstances would be a relatively low P soil test value, minimal incorporation of broadcast P and relatively dry surface soil conditions. Contrary to many recommendations where less fertilizer P is recommended for band application compared to broadcast (situation B), the optimum rate of band-applied P for these conditions may be higher than for broadcast applications.

Situation D: Broadcast more efficient than band.

This type of response is most likely on low P fixing soils that have heavy residue cover and a warm, moist soil surface. These conditions may exist in no-till systems in humid environments or for irrigated no-till. When these conditions exist, root density is frequently highest at the soil surface where broadcast P is located. Band treatments may be less effective because of insufficient root contact.

Back to the Questions

Is it better to band or broadcast? The answer depends on the specific conditions likely to be encountered. The factors affecting crop response to fertilizer P must be considered along with the hypothetical response types that are possible. Rate adjustments, if any can be developed when the most likely response type is determined. The question seems simple but the answer involves an integration of complex factors.

Summary

Discussions of P placement have a common problem: overgeneralization. There are exceptions to nearly every placement rule in the book.

In general, if there is a difference in crop response due to P application method, band applications will perform equal to or better than broadcast applications. Broadcast applications are seldom superior under Great Plains conditions.

In addition to agronomics, other factors are equally important in selecting the best P application method. Equipment availability, labor requirements, product availability and availability of operating capital all affect this decision.■

Band Placement of Phosphorus Helps Alfalfa Establishment in a Dry Year

By Everett D. Thomas

Dry weather in the seeding year for alfalfa makes the benefits of band placement of fertilizer, especially phosphorus (P), more apparent, as shown in this New York study.

THE ADVANTAGES of band placement of fertilizer for forage seedings have been recognized for many years, especially where soil fertility is less than optimum.

The primary nutrient required for vigorous seedling establishment is phosphorus (P). It is especially important to have P placed directly under the seed. And it is never more critical than when the forage seedling is struggling to become established during an extended period of dry weather. We had a good example of the difference between broadcast and banded P in 1988 at the William H. Miner Agricultural Research Institute in Chazy, New York.

Using a press wheel grain drill, we seeded a 13-acre field to alfalfa on April 21. The soil was a Massena stony loam with medium P and potassium (K) levels. On part of the field we used a band application of 150 lb/A of a 6-27-27 blended fertilizer. On the other portion, we used the same fertilizer and rate, but material was broadcast rather than banded.

We had two inches of rain within a week of seeding, then very little precipitation between the end of April and June, when the photo was taken. At left in the photo is the band-seeded alfalfa; on the right is the alfalfa with broadcast fertilizer. The differences were considerable and persisted until first harvest. The band-seeded alfalfa not only had more early growth, but also produced more first cut dry matter.

Band-seeding with a fertilizer containing P is advisable for most situations, but with adverse weather conditions P placement becomes critical.■

THE DRAMATIC difference in growth of these alfalfa plots is due to P placement at seeding in a dry year. Area at left was banded-seeded, while the plot at right received the same fertilizer rate broadcast.

Mr. Thomas is an agronomist and farm manager with the William H. Miner Agricultural Research Institute, Chazy, New York.

Dr. S.L. Tisdale, Former President of The Sulphur Institute, Dies of Stroke

DR. SAMUEL L. TISDALE, 70, died January 16, 1989, of a massive stroke. He had resided in the Washington, D.C., area for several years.

He is survived by his wife, Allyne Darby Tisdale, of Rockville, Maryland, and other relatives.

Dr. Tisdale retired in 1984 as President of The Sulphur Institute. He had been affiliated with The Sulphur Institute since 1960 in various positions, serving as President since 1979.

After receiving his bachelor's degree in agricultural science at Auburn University in 1942, he served more than four years in the U.S. Army as a parachute artillery officer. His service in the southwest Pacific ended when he was injured and returned to the states, where he spent several months in military hospitals.

S.L. Tisdale

Dr. Tisdale earned his Ph.D. in soil science and nutrition at Purdue University in 1949. He joined the staff of North Carolina State University and later also directed the soil testing division of the North Carolina Department of Agriculture. He was southeast regional director of the National Plant Food Institute from 1958-60.

Dr. Tisdale is the author and co-author of numerous technical and popular articles and co-author of *Soil Fertility and Fertilizers*, an internationally-used college text. ■

In Memory of Herman Warsaw

HERMAN C. WARSAW of Saybrook, Illinois, passed away on March 19, 1989, at the age of 79. He is survived by his wife, Evelyn; daughter, Ilene Bickel; three brothers, a sister and other family members.

While friends and family paid their last respects at the funeral service on the central Illinois prairie, the inspiration Herman Warsaw gave to people around the world will live on.

Through his example, Mr. Warsaw challenged numerous individuals to try harder as better stewards of the soil, better farm managers, better researchers. Since 1979, when he first set the world's corn yield record for non-irrigated corn at 338 bu/A, thousands of farmers, scientists, government officials and others have walked his fields and shared his ideas. Thousands have also heard him speak about his corn production practices at meetings throughout the U.S. and Canada, and as far away as New Delhi, India. Visitors from around the world have dug in the soil of his fields to observe corn roots, and they have listened to his philosophy under the maple tree in his front yard.

In 1985, a new world record of 370 bushels per acre for non-irrigated corn was recorded on the Warsaw farm. His motivation throughout the years was to leave the Illinois prairie land he farmed a little better than he found it.

Herman Warsaw

An avid conservationist, Mr. Warsaw believed — and demonstrated — that high yield management practices can be in harmony with protecting and improving the productivity of the soil.■

This notice was prepared by Dr. Harold W. Reetz, Jr., Westcentral Director of the Potash & Phosphate Institute (PPI), who lives near Monticello, Illinois, and worked closely with Mr. Warsaw in recent years.

Courage

Behold the turtle; he makes progress
only when he sticks his neck out.

Agricultural scientists are largely responsible for the fantastic accomplishments in food and fiber production in the world. Their training, experience, research, and educational programs have created better cultural practices, improved varieties, higher yields, and conservation of natural resources. They have pioneered in newer farm machinery and proper use of agricultural chemicals.

Their goal: reach the yield level that results in best quality and profit while conserving soil and water. Agricultural scientists are too modest. They don't receive enough credit for their contributions.

Today an affliction is spreading in America that some call "chemophobia". It thrives on misinformation, sensationalism, and political activism. It feeds on fear of the unknown and scientific illiteracy, and it is contagious. To those in its grip, science seems to lead to environmental and biological degradation—born mostly of corporate greed. The media, limited in scientific background, often advance this dark view. They seldom acknowledge science as an invaluable tool for protecting and improving life.

Now is the time for agricultural scientists to assert themselves—to call on research and knowledge accumulated over the years—**facts** about wise use of chemicals to produce at yield levels that result in lower costs per unit and that avoid erosion and pollution. They have the true story on "organic farming"; they know how plants take up nutrients; they won't promote excessive use of chemicals; their data prove the most desirable and conserving levels of production.

Have courage, agricultural scientists! Proclaim the **facts** on best management practices, most economic yields and judicious use of chemicals.

—*J. Fielding Reed*

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