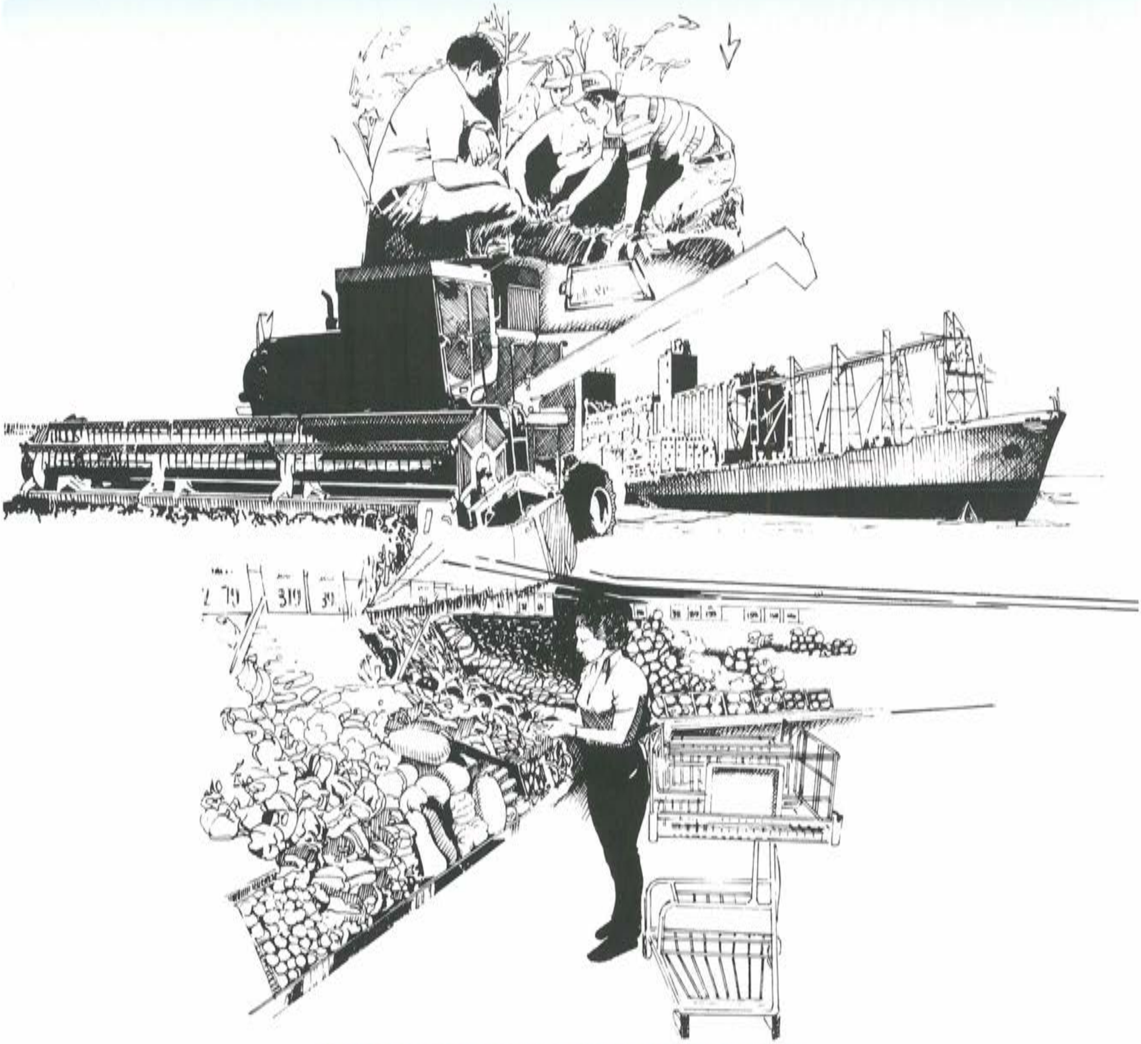
BETTER CROPS

WITH PLANT FOOD

Fall 1990



AGRICULTURE: Feeding the World through Research and Education

BETTER CROPS With Plant Food

Vol. LXXIV (74), No. 4 Fall 1990

BETTER CROPS WITH PLANT FOOD (ISSN: 0006-0089) is published quarterly by Potash & Phosphate Institute (PPI), 2801 Buford Hwy., N.E., Suite 401, Atlanta, GA 30329. Phone (404) 634-4274. Subscriptions: Free on request to qualified individuals; others $8.00 per year or $2.00 per issue.

Contents

Our Cover: Soil fertility research and education for innovative, conventional production agriculture are keys to meeting the challenge of world food needs.
Illustration by Charles Hamilton

Feeding the World: Can We Do It?

By B.C. Darst and D.W. Dibb

The earth and its wealth of natural resources have sustained people, plants and animals throughout history and will continue to do so . . . at least for a while. We must recognize, however, that the level of population and food production the earth will support is finite. We have not yet identified the limits, but they lie in wait for us, somewhere out there in the future.

STEWARDSHIP is the key to our being able to continue to feed a growing world population . . . stewardship that protects our soil and water resources, including the efficient use of our energy supplies. A part of good stewardship is the development . . . and utilization . . . of new technology. Another is making more efficient use of present technology. The North American farmer, through adoption of improving technology, is a good steward . . . as he must be. Why?

First of all, there are fewer farms and farmers. Fifty years ago, there was one farm for every 21 people in the U.S. Today, there is only one for every 115! Where have all those farms and farmers gone? The farmers (actually, their sons and daughters) moved to town; most of the farm acreage is still there, but is being managed by fewer individuals.

As farm numbers dropped and sizes increased, farming methods changed to meet the needs of increasing food demands. Labor and limited inputs were replaced with equipment, commercially produced fertilizer and manmade pesticides, along with improved hybrids, varieties and other production inputs. Yields per acre increased dramatically; our ability to produce safe, abundant food spiraled upward.

The ratio of farms to people will probably continue to widen as more of us are freed to exercise the choice of careers outside agriculture. That puts more pressure on the farmer to grow the food we will need and continue to practice good stewardship for sustained increases in food production.

Another reason why farmers must continue to be good stewards is that they are in the world's spotlight. We are all more environmentally conscious today, urban and rural citizens alike. We want our soil resources protected and our water supplies as pollution-free as possible. The farmer works with and affects both soil and water . . . he must if he is to continue to produce food for our survival.

Fortunately, good management . . . stewardship . . . associated with efficient food production and resource protection go hand in hand. Unfortunately, the majority of urban citizens do not understand this, but rather have been led to believe otherwise in many instances.

Projections are that world population will double during the next half century. Where will we get the food to feed all the people?

These are hard questions, and their solutions go beyond our ability to simply grow food. Trade barriers, political and economic constraints, wars and the threat of wars, food distribution systems . . . all those factors impact on our ability to feed the hungry. Can we overcome these obstacles and eliminate hunger? So far, we have not. Time will tell if we can.

This *Better Crops* is an informational issue which addresses topics on research, fertilizer use efficiency, environmental protection and sustainability of crop production. All these are important considerations facing farmers as stewards of our soil and water resources. ■

Dr. Darst is Vice President of the Potash & Phosphate Institute (PPI) and President of the Foundation for Agronomic Research; Dr. Dibb is President of PPI, Atlanta, GA.

Fertilizer Nitrogen: Providing Food and Protecting the Environment

By R.G. Hoeft

Perception is a major concern with nitrogen (N). Much of the recent focus on this nutrient has dealt with potential negative effects on water quality and human health. To place N in the proper perspective as an essential input to food production, its positive aspects must be weighed against any possible negative impacts it might have.

PROTEINS, N-containing compounds, provide the sustenance humans require in their diets in order to survive. Protein requirement varies by age, from 23 grams (less than an ounce) per day for very young children to 56 grams (about two ounces) per day for adult men. Assuming an average of 40 grams per day per person for the entire world population, annual consumption would be in excess of 110 million tons of protein.

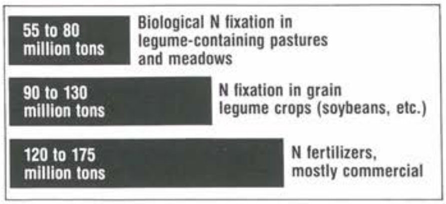
Neither plants nor humans are very efficient in harvesting N and converting it to protein. This inefficiency results from biological and environmental factors in the soil-plant system, multiplication of inefficiencies as plant proteins are converted to human proteins, and the inefficiencies of the human race in harvesting, storing, distributing and processing food. While it is difficult to quantify, the ultimate N harvest efficiency by humans is probably less than 20 percent. As a result, the amount of N required by society is several magnitudes greater than that indicated for protein needs.

In reality, a readily available source of N is needed to meet this protein requirement, plus provide the fiber for housing, clothing and other necessities of life. Commercially-produced fertilizer, available and manageable, will continue to increase in importance to meet the protein demands placed by a growing world population.

World Nitrogen Requirements Are Increasing

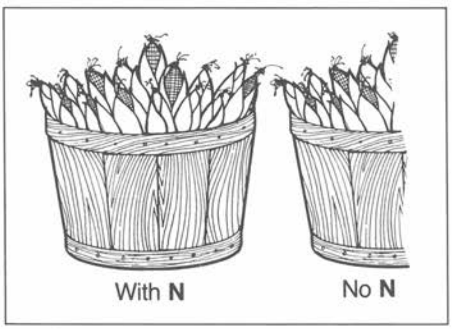
It is estimated that annual need for N may exceed 275 million tons by the year 2000. Ninety to 130 million tons will come from grain legume crops such as soybeans, with another 55 to 80 million tons provided through biological N fixation in legume-containing pastures and meadows. The remaining 120 to 175 million tons will be supplied by fertilizers, most commercially produced. This is significantly higher than the current world usage (about 70 million tons of fertilizer N) because of the need for more food and fiber and because of the decrease in supply of N from organic matter in soils.

Dr. Hoeft is Professor of Soil Fertility, Department of Agronomy, University of Illinois at Urbana.



WORLD need for N could top 275 million tons annually by the year 2000. Most of the N will come from commercial fertilizer.

Although N is but one of 16 elements essential for plant growth, it is one of the most critical. It is the one most frequently deficient in agricultural soils.Recent estimates by 15 U.S. scientists indicate that corn yields would decrease 40 to 50 percent if fertilizer N were eliminated.These estimates agree with those of agricultural economists at Iowa State University, who evaluated the impact of shifting from conventional to organic farming.They projected yield reductions of about 50 percent if fertilizer N and pesticide use were terminated.



SCIENTISTS estimate U.S. corn yield would be cut by more than 40 percent without N fertilizer.

Many soils of the world were inherently productive when they were first tilled. Tillage results in the decomposition of organic matter . . . thus release of N. With continued farming, these soils have reached, or are approaching, an equilibrium level of organic matter. As that equilibrium is established, there will be no net release of available N, merely a recycling of that contained in organic matter returned to the soil through crop production management systems.

Environmental Effects of Nitrogen

In recent years, questions have been raised about the effects of N fertilizers on the environment and, consequently, on human health. Environmental concerns center on the movement of nitrates through soil into water systems . . . both surface and groundwater supplies.

Over the last several years, analyses of samples from domestic and community water supplies have shown nitrate levels in excess of the public health standard of 10 parts per million (ppm) nitrate-N at some time during the sampling period. However, until recently there has been no organized sampling program designed to identify the magnitude of the problem. The U.S. Environmental Protection Agency (EPA) is currently conducting a national survey of domestic and community wells.

As of Sept. 30, 1989, EPA had completed the analysis of 295 wells, consisting of 180 community and 115 domestic wells. Of those, eight (less than 3 percent) had levels in excess of the 10 ppm standard. Only 145 (49 percent) tested positive for nitrates. Since most well water, at some time, passes through soil that contains nitrates, it is surprising that more did not contain detectable levels of nitrates.

In at least some instances, high nitrate levels have resulted from natural causes. Water analyses in the mid-1800s in Washington County, IL, indicated levels of roughly 50 ppm nitrate-N (213 ppm nitrate) . . . five times the public health standard. Since agriculture was still in its infancy at that time, it is doubtful that it was the cause of the high nitrate levels.

Chemical Analysis of Water
Okawville, IL - 1860

Calcium	266	Nitrate	213
Magnesium	170	Sulphate	710
Sodium	293	Chlorine	477
Potassium	19		

Units are parts per million (ppm)

Agriculture has its greatest influence on nitrate-N concentration in streams during late winter and early spring when

(continued on next page)

(Nitrogen . . . from page 5)
crop growth and development are low. This low crop N use coincides with the time period of increasing soil biological activity and, thus, the release of N from organic matter. Also, some losses occur as a result of N being applied for use by the following crop. It is difficult to determine the relative losses from these two N sources. However, a Minnesota study indicates that the amount of N lost into drainage tile lines following soybeans is slightly higher than that lost following corn fertilized in the spring at a rate adequate to provide optimum yield. (Fall application of comparable N rates resulted in slight increases in N loss through the tile lines.)

Some have suggested that continued use of fertilizer N, particularly anhydrous ammonia, will destroy biological organisms in the soil. Research in Florida and Texas several years ago clearly showed that not to be the case. Others have suggested that continued use of fertilizer N will destroy the physical and chemical properties of the soil. Results from both Kansas and Nebraska research have disproven that theory.

Agriculture, including the use of N fertilizers, is an energy-demanding process. However, it is also one of the few processes of either nature or man that results in a net gain in energy. When applied at proper rates, there is a net energy harvest in the grain of about four units per unit expended to produce, transport and apply N fertilizer.

Human Health Concerns

Consumption of excess levels of nitrates has been shown to cause a condition called methemoglobinemia (blue baby syndrome) in infants. At birth, the gastrointestinal tract of infants is not sufficiently acid to prevent the growth of bacteria that convert nitrate to nitrite. Hence, a heavy intake of nitrates can lead to toxic levels of nitrites being formed and absorbed into the blood stream. While the primary concern is with nitrate levels in water, it is important to consider total nitrate intake, including that from foods, in properly evaluating the situation. Some of the leafy vegetables fed to young infants, namely spinach, are known to contain high nitrate levels.

Where nitrate levels of water are known to exceed the standard, acceptable water . . . with a nitrate concentration of less than 10 ppm nitrate-N . . . should be obtained from other sources for infants under one year of age. (Boiling high nitrate water serves to increase rather than decrease the concentration, so should not be done.)

There is no question that an increase in methemoglobinemia is associated with increased levels of nitrate in the water supply. However, studies dealing with this subject do not conclusively implicate nitrates because they do not report what else might be in the water. Quite often, high nitrate water contains other contaminants as well. Further, the relationship between nitrates in water supplies and health is not strong. Medical science has reported little difference between those infants that consumed high nitrate water all year and those who received low nitrate water.

Nitrate (NO_3-N) in Water (mg/l or ppm)				
0-10	11-20	21-50	51-100	>100
Cases of Infant Methemoglobinemia				
0	5	36	81	92 (39 Deaths)

The relationship between nitrates and other human health problems has not been extensively evaluated. What work has been done has not shown any clear adverse effect of nitrates on either heart disease or cancer. In fact, an Illinois study of a population of nearly 600,000 indicated no change in the rate of cancer deaths for the male population associated with a difference in nitrate level of the water consumed. On the other hand, the lowest nitrate levels had the highest death rate for total and food tract cancers for females. Similarly, a recent Pennsylvania study concluded that fertilizer use was largely unrelated to cancer mortality. In the one case where it was statistically significant (digestive cancer), **it was negatively related.**

Urban Impact on Water Quality

There are good indications that agriculture is not the only source of increased nitrate levels in water supplies. Indeed, recent studies indicate that urbanization may be a major factor in some areas. It was important in explaining the majority of the variance associated with nitrate-N during roughly 50 percent of the year in one Illinois watershed.

A recent study at the University of Illinois evaluated the theoretical effect of urbanization on nitrate levels in streams. It assessed the impact of shifting from corn and soybean production to housing. On a quarter section of land . . . 160 acres . . . a model was developed with the assumption that 100 acres would be developed as residential housing, the remaining 60 acres left in corn and soybeans. The model placed the quarter section between 400 and 1,000 feet from a stream. The shift to partial housing showed an increase in nitrate concentrations of 50 percent in the stream.

"There are good indications that agriculture is not the only source of increased nitrate levels in water supplies. Indeed, recent studies indicate that urbanization may be a major factor in some areas."

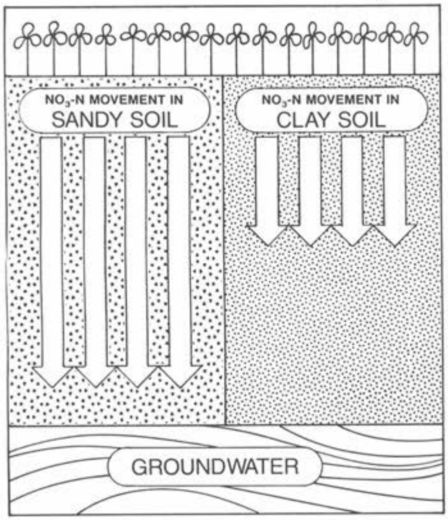
Why such an increase in nitrates from urbanization? Many home owners use far higher rates of fertilizer for lawns and gardens than are necessary. Although these citizens obviously are not aware of the potential environmental damage they do, they may be among those who quickly point an accusing finger at agriculture when environmental contamination becomes an issue.

Using Nitrogen Fertilizers Safely

Is society now at an impasse between the use of fertilizer N to produce the quantity and quality of food and fiber needed to feed, clothe, and house the people of the world and the purported risk to the environment and human health? The answer to that is "NO".

While there are areas where N fertilization practices have adversely affected water quality, these are, for the most part, related to specific environmental conditions or to point sources of contamination usually caused by inadequate management.

With the limited data base now available, it appears that the major environmental threat exists in areas of intense crop production on sandy soils. The relatively low water holding capacity of these soils allows water to move greater distances in shorter periods of time. As water moves through soil, it will carry soluble nutrients below the rooting zone.



NITRATE is more likely to move downward in sandy soil than in clay soil.

Additional research is currently underway by land grant university and USDA scientists to identify improved N fertilizer management techniques that will reduce the potential for nitrate movement into groundwater in these situations. Much remains to be learned.

Point sources of contamination are usually associated with human error, such

(continued on next page)

(Nitrogen . . . from page 7)
as fertilizer spills or inadequate management of waste materials in and around wells. It is not unusual to find high levels of bacterial contamination in some wells having high nitrate levels. This is often due to poor well construction or to the topographic position of livestock-holding facilities which results in run-off of livestock wastes into the well. Better use of known technology will help minimize these potential problems.

On the heavier soils with higher clay contents, movement of N from agricultural land into water supplies has not been shown to be a major problem. As pointed out earlier, less than 3 percent of all wells sampled had nitrate levels in excess of the public health standard. Unfortunately, a base level from years preceding intensive agriculture is not available to determine whether or not that has changed. In other words, it is not possible to determine the amount of contamination that might be naturally occurring. It is unlikely that much could be done to correct those situations where nitrate levels in water supplies are naturally high.

Movement of some N into surface and groundwater supplies will continue as long as soils are biologically active. However, man has the knowledge to minimize the rate of such movement to levels that will be acceptable for the preservation of the environment.

Summary

Technology based on sound research will continue to be developed to reduce the potential for movement of nitrates into our water supplies.

Farmers and their advisors have done a remarkably good job of designing fertilizer programs to minimize the potential for N loss to the environment. They have more incentive for such programs as the loss of N translates into an economic loss. In addition, the farm family is at greater risk of having contaminated water as most farm wells are shallow and close to the land area receiving fertilizer N.

Agriculturalists must continue to fine-tune fertilizer programs. They must eliminate

". . . a base level from years preceding intensive agriculture is not available to determine whether or not that has changed. In other words, it is not possible to determine the amount of contamination that might be naturally occurring. It is unlikely that much could be done to correct those situations where nitrate levels in water supplies are naturally high."

those situations, although limited in scope, where excess rates of fertilizers relative to the management ability of the farmer or the productive ability of the soil type are being used. Regardless of the apparent negligible effect of N on human health, we must strive to keep nitrate levels low in our water supplies. Such loss of fertilizer N is not good economics nor is it good for the environment.

Fortunately, we do have available technology to allow us to manage our food production system to keep N out of our water supplies. That technology includes:

- Timing of N applications to fit plant needs
- Use of nitrification inhibitors to slow formation of nitrate
- Multiple applications of N to fit plant needs
- Application through irrigation water
- Specific placement of N-containing fertilizers
- Use of appropriate N sources
- Use of rates appropriate for yields of crops to be grown
- Use of adequate amounts of phosphorus (P), potassium (K) and other nutrients to maximize N use efficiency.

There is no contradiction between fertilizer N use and adequate food production with minimal environmental risk. We do have a problem with perception, however. We can change that perception, protect the environment **and** feed the world's hungry through the effective management . . . and promotion . . . of production agriculture.

It's up to those of us involved in the business of growing food to get the job done. ■

Is Research Losing Its Relevance?

By Earl L. Butz

TODAY there is a pervasive attitude in our land grant universities that applied research work is not important. This is especially true among the younger generation of agricultural scientists and assistant and associate professors on the way up.

They recognize, probably too often, that the main criterion for promotion is publishing in scholarly journals. They do research to advance knowledge for knowledge's sake, write for their peers, and present to their dean (and promotion committee) a list of publications that, in many cases, even the dean cannot understand. They feel little responsibility to contribute to the once basic institutional mission of solving society's applied problems. From purely a personal point of view, they are probably right; this is not where the payoff comes.

To make matters worse, the published papers by these bright young staffers are so mathematical and analytical as to discourage the policy maker from spending much time trying to understand them. One need only open at random any recent issue of a technical journal, take a look at the complicated formulas and deeply technical language, to understand why the policy maker, in USDA, Congress, the media, or in farm organizations, seldom finds any helpful practical material.

Perhaps the need is twofold. First, a larger share of our research effort should be directed toward the analysis of practical problems, either currently existing or anticipated. Second, we need to encourage (and reward) a third group of agricultural scientists—those who can bridge the gulf between the theoretical researcher and the ultimate user, whether that person be on the farm, in agribusiness, or in politics.

We need Extension specialists and researchers who can communicate with the man in the street and with the representative in the Congress. Unfortunately, this is not the college position that comes up first for promotion in academic rank.

The Practical Scientist Is More Essential Now Than Ever Before

Never before in our history was the opportunity greater for competent and objective agricultural scientists with a practical bent for lay communication. The level of agricultural literacy of the public must be raised if sound agricultural philosophy on a continuing basis is to find expression in our legislative halls. Sound governmental decisions in the agricultural area can never go very far ahead of the level of agricultural literacy of the people.

Agricultural literacy influences present legislation as well as the thinking of our leaders a generation hence. So it is that all of us need to be convinced that sound public policy formulation thrives only in the soil of rising agricultural literacy among all our people.

One of the greatest challenges facing the agricultural scientist involved with public policy in America is to cast his influence on the side of keeping government the servant of agriculture, not its master. To accomplish this, we must bring more of our research down to a more practical plane of public policy formulation and administration.

For the individual scientist, this may be less exciting in the short run, but in the long run it will yield large dividends in the form of a progressive agriculture and a strong America. ■

Dr. Butz is former U.S. Secretary of Agriculture and is Dean Emeritus of Agriculture, Purdue University. This article is extracted from a paper published in the American Journal of Agricultural Economics, Vol. 71, No. 5, December 1989, titled "Research That Has Value in Policy Making: A Professional Challenge".

The Importance of Soil Fertility Research

By Charles A. Black

Past research has clearly indicated that sustaining and increasing soil productivity require substantial additions of plant nutrients. Continued research that seeks to improve the balance between nutrient additions and nutrient needs will improve agricultural profitability and enhance environmental quality while helping agriculture meet the long-term worldwide food requirements of society.

ONE OF THE PRINCIPLES of soil fertility is that nutrients are needed to grow crops. If the nutrient supply is deficient, crop yields decline.

According to a myth of long standing, however, high crop yields can be sustained without adding nutrients to the soil, while continuing to sell nutrients in harvested crops to nourish people or livestock located elsewhere. The way to sustain the yields is said to be to grow legumes to fix nitrogen (N), and to use crop rotations and proper management. These practices equate to "motherhood" and "apple pie" in the good book of soil fertility. But in reality, they only slow soil fertility decline.

The emphasis in the popular press is on alleged excessive use of fertilizers and other agricultural chemicals, and on the need to cut back or eliminate these uses to preserve the environment. Excessive use in some areas is a fact. The Netherlands is a particularly heavy user of fertilizers, with agricultural land receiving more than eight times the total amounts of N, phosphorus (P), and potassium (K) applied per unit of agricultural land in the United States.

In the Netherlands, imported nutrients in the form of animal feeds have been profitable, but it has not been profitable for producers to export the nutrients in the animal manure. As a result, manure is sometimes considered more as a waste that must be disposed of than as a fertilizer resource. The unneeded quantities of manure applied to agricultural land have caused concern. Legislation now limits the P that can be added in manure, and consequently the animal population per unit of agricultural land available for manure disposal in the Netherlands. A similar situation regarding manure disposal exists in isolated areas in the United States.

Soil fertility research has long since proven that sustaining and increasing soil productivity require additions of plant nutrients—not in quantities as great as those being added in the Netherlands and some other places, but still substantial. Most farmers in developed countries depend upon mineral fertilizers to meet their soil fertility needs. **The fact that fertilizers must be purchased limits the amounts applied, and as a result, many farmers could increase their profits by using more fertilizers than they do. At the same time, some farmers are using amounts in excess of those that pay off economically.**

Responding to environmental concerns, much of today's soil fertility research is related to N loss from soils in drainage water. **This work is yielding a better and more quantitative picture of N behavior than we had previously, and it is pointing the way to more precise control of N fertilizers so they will produce the desired yield effects with less loss than has occurred in the recent past.**

The addition of unneeded amounts of nutrients in some areas in developed countries is well publicized, and the is-

Dr. Black is Distinguished Professor Emeritus, Department of Agronomy, Iowa State University, Ames, IA.

sues are being addressed. But in stark contrast, the soils in developing countries usually receive far smaller amounts of nutrients than are required to meet crop needs. The causes are complex,and include excessive populations, poverty, and inappropriate government policies. Attempts of the populations to sustain themselves have led to depletion of soil nutrient supplies and to excessive soil erosion.

The success of the Green Revolution is evidence that under proper conditions great strides can be made in food production in developing countries. As pointed out by Dr. Norman Borlaug, a complex package of conditions is needed. The requirements include government policies that will increase the incentives for production and will provide the required fertilizers, pesticides, and improved seeds . . . together with support for the research needed to develop the appropriate technology.

Technology can be imported in a rough form, but development of appropriate technology requires research under local conditions. Supporting this research requires great political will. The soil fertility and soil management research needed to produce efficient and sustainable production systems requires a long-term political commitment that is difficult to generate in all countries. Politicians are understandably concerned about the short-term, even if the long-term outcome of some of their policies may be undesirable. The long-term problems will belong to someone else.

A reorientation of government policies in developing countries to provide the incentives and required fertilizers and other production inputs could very quickly result in increased agricultural productivity. With research, the practices could be tailored to the conditions. Whether this advance would turn out to be yet another temporary solution to human needs for adequate food would depend upon whether population could be brought under control.

While recognizing the inestimable value of increased fertilizer use in producing food for currently undernourished populations, thought needs to be given also to the long-term consequences of increased fertilizer use. Increased use is not an unmitigated good.

Except for N, the supplies of plant nutrients for fertilizer use are finite and limited. In the United States, we are using our nutrient supplies the same way we used our petroleum supply. To use the words from a once-popular tune, "Those were the days, my friend, we thought they'd never end." We can see now the early consequences of our national policy on petroleum: increasing dependence upon foreign sources, and increases in price.

The consequences of our national policy on the use of nonrenewable supplies of plant nutrients are not yet evident, but they will appear in time. Soil fertility research will not eliminate the use of these nonrenewable resources, but it can help to conserve supplies by improving the efficiency with which they are used. Sooner or later, our descendents must face the specter of deficiencies.

A long time may yet be required before policy makers react to the inevitability of the long-term problem. After all, soil testing is one of the most important practical products of soil research, but in my opinion the field research necessary to support this effort has been shortchanged fairly consistently in terms of financial support.

Improved balancing of nutrient additions with nutrient needs and economics will yield benefits for those who consider the issue to be environmental quality, as well as those who are concerned about the economics of agricultural production and the long-term, worldwide food requirements of society. ■

Latin American Soybean Research: Observations and Implications for U.S. Competitiveness

By Edward S. Oplinger and Harold F. Reetz

The percentage of world soybean production supplied by South America has steadily increased in the last two decades. Exports of soybean meal and soybean oil from Brazil and Argentina now exceed that from the U.S. This production expansion is the result primarily of acreage expansion rather than Latin American research efforts. While most of the initial research was adaptive in nature, current research programs in both Brazil and Argentina are emphasizing improvements in efficiency of production for current production areas along with research to expand the production into new areas. To remain competitive in the world market, the U.S. must maintain and strengthen ongoing soybean research programs.

DURING THE 1980s, the U.S. dominance of world soybean production and exports was greatly reduced by the steady increase in production and exports of soybeans by Brazil and Argentina. Economic incentives and government policies both in the Latin American countries and in the U.S. fueled the rapid expansion of soybean acreage in Brazil and Argentina, while soybean acreage in the U.S. declined. In 1988-89, soybean production in Brazil and Argentina was 1.08 billion bushels compared to U.S. production of 1.54 billion bushels **(Figure 1)**. Brazil and Argentina each now export more soybean oil **(Figure 2)** and soybean meal **(Figure 3)** than the U.S.

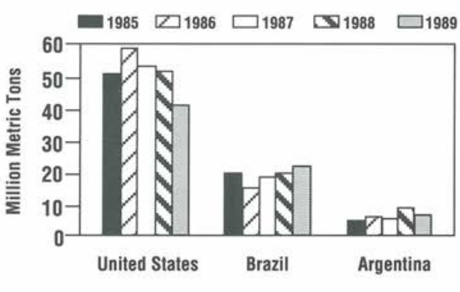


Figure 1. Soybean production.

Is this rapid increase in competition from South America due to export of U.S. technology? While it is true that some of the best South American soybean scientists received their training in the U.S., the main factor in acreage expansion appears to have been government policies. Another important factor is that adoption of new soybean production technology appears to occur much faster in South America than in the U.S. Latin American research has focused on the application of technology, while U.S. efforts have recently been more focused on development of new technology, with reduced emphasis on application of technology to production and production costs.

Soybean Study Mission

In March 1989, a group of U.S. soybean research and extension specialists visited soybean research facilities in Brazil and Argentina on a two-week mission to learn first-hand about soybean research, production, and processing in South America. The observations of the group were summarized by Dr. P.A. Miller, ARS/USDA National Program Staff.

Research Emphasis in Brazil and Argentina. Both countries have vigorous

Dr. Oplinger is with the Department of Agronomy, University of Wisconsin-Madison. Dr. Reetz is Westcentral Director, Potash & Phosphate Institute (PPI), Monticello, IL.

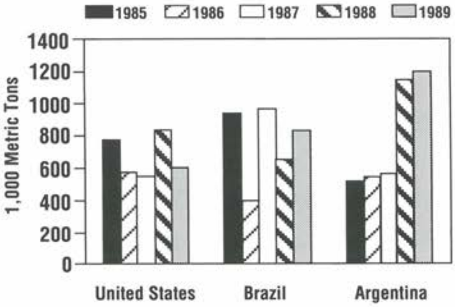


Figure 2. Soybean oil exports.

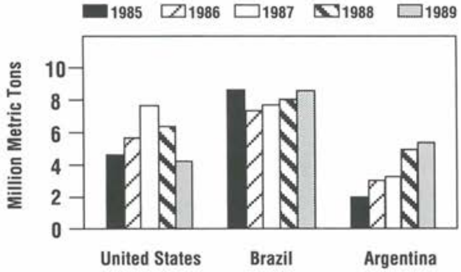


Figure 3. Soybean meal exports.

research programs for improving soybean production efficiency. Initial research was primarily "adaptive" in nature, such as evaluation of U.S. varieties, cultural practices, and pest management for direct application in their countries. Current research is shifting to modify and refine U.S. technologies to better match local soils, climates, pests, and cropping systems.

Agencies and Facilities. Most production research is conducted by INTA in Argentina and by EMBRAPA in Brazil. EMBRAPA is completing a new soybean research facility at Londrina with funding from the World Bank. Over 50 professional scientists will work at the new facility with the latest dry and wet laboratories, greenhouses, and nearly 800 acres of field research plots. They also have the latest in mechanized field research equipment. University scientists also do some research, but most of their effort is directed toward teaching. The private sector is involved in conducting adaptive demonstrations of proprietary varieties and chemicals usually developed elsewhere. Some U.S. companies have initiated breeding programs in Argentina to develop varieties more suited to local needs.

Production Expansion. Both countries have initiated research to expand soybean production to new areas. About 90 percent of the production in Argentina is in the Humid Pampa, but research is directed at expanding to the north and south. Brazil appears to have great potential for expansion into new areas, especially in the Cerrado, north and west of the present production region. A soybean breeding research project at Londrina seeks to utilize the "juvenile" gene to expand the area of adaptation of current varieties into the lower latitudes. One breeder on this project expects to see soybean acreage in Brazil expand at the rate of 7 percent per year.

New Technologies. The mission group did not find new technology that would be of direct benefit to U.S. scientists or producers, but did identify some areas that were impressive.

- Development and use of microbial insecticides to control velveteen caterpillar on over one million acres in Brazil.
- An extensive data base in Argentina relating soybean yield to soil moisture, temperature, and other climatic variables over a wide range of locations and years. (This data base could be of value to U.S. physiologists and modelers developing soybean growth simulation models).
- No-till and reduced-tillage systems developed and evaluated by EMBRAPA and selected farmers in Brazil for growing soybeans on erodible and low organic matter soils demonstrates long-term benefits of reduced tillage systems on these soils.

Research Support. In addition to government support for soybean research through the government research institutions and the universities, there is considerable farmer support for research in South America. Brazil soybean growers,

(continued on next page)

through the farmer cooperative, "check-off" about 1 percent of the farm value of their production to support research demonstrations and extension activities. This program insures rapid transfer of new technology directly to the growers.

Implications for U.S. Research

The U.S. soybean producer is now facing serious competition in the world markets, particularly from Brazil, and to some extent from Argentina. The South America Soybean Study Mission members concluded that if U.S. soybean growers are to retain competitiveness in the world markets, ongoing soybean research programs must be strengthened in the following areas.

- Strengthen production research to reduce costs of production per bushel.
- Strengthen research on processing quality to improve protein and oil constituents of U.S.-produced soybeans.
- Emphasize production systems that combine individual components of production and quality technology—possibly including computer-based aids for management decisions.
- Balance production and environmental concerns by developing conservation measures that are economically acceptable to the stability of the farming operation.
- Accelerate the technology transfer process from research to use on the U.S. farm.
- Invest in longer-term basic research to be able to solve future problems. Metabolic pathways associated with yield and quality, mapping of the soybean genome, and more precise methods of gene transfer are examples.

Quality of U.S. Soybeans in the Export Market

Perhaps one of the greatest challenges for competitiveness of U.S. soybeans in the world market is the quality of the soybeans put into the market. The American Soybean Association has determined that the two principal quality factors that impact U.S. soybean competitiveness in the world market are foreign material and composition. The information in **Figure 4,** from a three-year summary of data from USDA/ARS, the Japanese Oilseed Processors Association, and Tagol (a large Portuguese importer and crusher), illustrates the quality problem to be addressed.

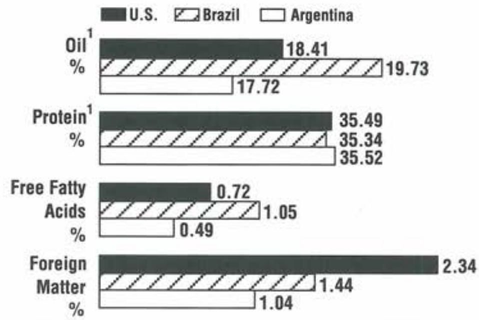


Figure 4. Comparison of U.S., Brazilian and Argentine soybean quality factors.
[1]13% moisture basis.
Sources: *USDA/ARS; Tagol* (Portugal); *Japan Oilseed Processors Association.*

Protein and Oil. There was no significant difference in protein content among the U.S., Brazil, and Argentina soybeans, but the Brazil soybeans had 1.3 percent more oil than the U.S. soybeans. This is equivalent to 0.78 pounds more oil per bushel, or about 15.6 cents per bushel more value. Removing more dry matter as oil also results in soybean meal with a higher protein content, a second strike against U.S. soybeans.

Foreign Material. U.S. soybeans are typically sold on the export market as U.S. #2 Yellow Soybeans, which allows a maximum of 2 percent foreign material (FM). South American origins guarantee a maximum of 1 percent FM at the time of loading. The 1 percent difference in FM translates to at least 6 cents per bushel advantage for Brazilian soybeans, not including the freight costs of carrying the foreign material from origin to destination.

This conservative 21 cents per bushel quality advantage of Brazil soybeans is added to a typical price discount of Brazil soybeans compared to U.S. soybeans.

Freight rates do favor U.S. soybeans, but not enough to make up the difference. The American Soybean Association is exploring legislative and research avenues that may help to improve the U.S. soybean quality through better grading standards and through better information on varietal and other factors affecting soybean quality.

Future Competitiveness of U.S. Soybean Producers

Will U.S. soybean producers be able to compete with their southern hemisphere counterparts? The answer lies in a combination of government policies, research and extension programming and budgets, and farmer initiative. We have the best research and extension systems in the world, and some of the best farmland and farm operators. But we need to work harder to utilize these resources, to support the programs that provide the technology, and to focus on the goal of being the low-cost producer of high quality soybeans for a more demanding world market. We can be competitive, but it will not be as easy as in the past. Proper action is needed now to improve production and efficiency and quality of U.S. soybeans. ■

Thai Deaths Linked To Low-Potassium Diet Lacking Fruits and Vegetables

THE MYSTERIOUS DEATHS of Thai workers abroad may have been caused by a lack of fresh fruit and vegetables in their diets, leading to low levels of potassium (K) in their blood, according to a team of Thai doctors.

The Nation and *The Straits Times,* newspapers in Southeast Asia, reported the story in April of 1990. Doctors arrived at the preliminary finding, which links the workers' deaths to similar cases among Thais living in northeastern Thailand, after five years of research in Ubon Ratchathani and Khon Kaen provinces.

Doctors from the medical faculty of Mahidol University in Thailand said the unexplained nocturnal deaths of northeasterners resembled the deaths of more than 600 Thai workers in Singapore, Saudi Arabia, Brunei and Malaysia.

Poor diet may be the reason for these deaths which, until now, have been blamed on a variety of factors, including poor living conditions, PVC pipes used for steaming rice and toxins in stimulants taken by the workers abroad.

The doctors said they had seen an increasing number of villagers complaining of muscle fatigue.

"Soon afterwards, we learned that some of them died in their sleep," said Dr. Sumalee Nimmannit, referring to a disease that has become known in the area as *lai taai* ("floating death"), and is widely believed by villagers to be caused by ghosts.

According to the doctors' tentative theory, many people in northeast Thailand do not eat enough fresh fruits and vegetables, leading to a K deficiency.

This in turn can cause extreme muscle fatigue in limbs, lungs and heart, and can eventually lead to respiratory or heart failure, researchers indicate.

High carbohydrate intake — such as pure rice diets — further lowers the blood K level.

When the Thai workers lack available cash, they sometimes eat nothing but glutinous rice, said Dr. Sa-Nga NilwarangKur. This causes a sudden increase of blood sugar within a few hours, which lowers the blood K level further.

"This might explain why so many people died in their sleep, only a few hours after dinner," he said.

Inadequate ventilation and crowded living conditions increase the danger for people already suffering breathing trouble from lung-muscle failure, he noted. ■

The Role of Soil Fertility Research in Developing Sustainable Food Production Systems

By Kenneth G. Cassman

What are the fundamental processes that link soil fertility management to changes in soil quality? A better understanding of characteristics of a sustainable agricultural system is essential for meeting global food production needs in the coming decades.

POPULAR CONCERN about the effects of human activities on the environment is increasing. This concern is evident in opinion polls and media coverage, and in the political agenda at the state and national levels.

While all economic sectors are under scrutiny, in agriculture these environmental concerns have generated a call for the development of sustainable agricultural systems that are less dependent on external inputs such as fertilizer-nutrients. The dominant cropping systems in the U.S. follow a management strategy that attempts to alleviate crop nutrient deficiencies by addition of fertilizers. Thus, the popular call for a sustainable agriculture implies that cropping systems based on this management strategy are not sustainable.

What Is a Sustainable Agricultural System?

In much of the dialogue about sustainable agriculture, participants promote or defend methods of farming that are defined with respect to the level or source of applied inputs.

This framework leads to classification of cropping systems as "organic", "alternative", "low-input", or "conventional". It diverts attention from the most crucial issue, namely: How must our cropping systems perform to be viable over the long term? Based on performance criteria, a sustainable agricultural system would have the following characteristics.

- It optimizes outputs (yield) relative to inputs while providing a total return on land, labor, or capital that is competitive with other livelihood options available to the farmer.
- It maintains or improves the resources (soil and groundwater supplies) on which agriculture depends.
- It limits effects on resources off the farm (e.g., groundwater, air, etc.) within acceptable standards of environmental quality, and it provides a safe workplace for those engaged in production activities.
- It contributes to the social welfare of rural communities and the society at large.

Defining sustainability in terms of performance avoids unfounded prejudgments about specific farming strategies. Instead, a system is sustainable if it meets these criteria over the short, medium, and long term.

The framework described also provides measurable standards, so researchers can evaluate the degree to which a cropping system meets the performance goals. The

Dr. Cassman is Associate Prof., Dept. of Agronomy and Range Science, University of California-Davis, Davis, CA 95616.

PLANTING of a corn-cowpea intercrop is shown on a hillside in Cape Verde, Africa. Most of the topsoil has been lost to erosion, leaving a very infertile and shallow soil. Stabilizing such cropping systems will require erosion control measures such as construction of retaining walls or planting of perennial crops across the slope, and inputs of nutrients to promote more rapid canopy development and ground cover. Without nutrient inputs, the low productivity of these systems does not provide sufficient incentive to farmers for investment in soil conservation measures.

standards include measures of biological efficiency which are important on our resource-limited planet. Outputs such as caloric yield (a measure of nutritional value and energy content) and protein yield versus the inputs of rainfall or irrigation, nutrients, and energy used in production are common units of performance that allow comparison of different cropping systems in diverse environments. These output/input ratios also lend well to economic analysis of costs, benefits, and risks.

An inherent assumption which underlies any concept of sustainability is that changes in soil quality (as defined by measurable chemical, physical, and biological properties) affect output/input ratios. This means that greater inputs of water, nutrients, and/or energy for tillage will be required to maintain yields in crop management systems that cause a decrease in soil quality. The inverse also applies. Although this concept is at the heart of the sustainability issue, the lack of strong experimental evidence to support the hypothesis attests to the superficial level of the present dialogue.

A Global Perspective of Sustainable Agriculture

Another important standard of on-farm performance is total output in terms of food value or economic return. The former is often neglected in discussions of sustainability, yet meeting the food requirements of an increasing world population dictates that farmers must increase yields in sustainable systems at a rate that is comparable to population growth.

It is often stated that global food production is more than sufficient to meet food demand, and hunger and famine are the result of inequitable food distribution and lack of purchasing power for those in need. Indeed, the 1980s were a decade of oversupply for many commodities. At

(continued on next page)

Soil Fertility Research . . . from page 18

issue for the future, however, is whether global food production will be adequate if we account for declining productivity in areas where soil and water resources are being depleted. If our projections come up short, famine will occur regardless of food and income distribution.

As a soil scientist who has traveled widely, my view of the global food supply-demand picture is not optimistic. Great expanses of the most productive irrigated land are threatened by salinization due to inadequate drainage. California's San Joaquin Valley, Egypt's Nile Valley, and vast areas in Soviet Central Asia surrounding the Aral Sea are notable examples. Likewise, irrigated systems that depend on geological aquifers, such as the Ogallala aquifer in the U.S., have a finite life of a few decades, and urban sprawl covers productive farmland at an alarming rate all over the world. Of still greater concern are the tens of millions of acres in developing countries where population pressures and social upheaval force farming on hillsides where horrifying rates of soil erosion endanger the persistence of these food production systems.

Even with optimistic assumptions about population growth, demographers predict a doubling to over 10 billion people in 45 to 50 years. To counter the loss of productive farmland occurring today, there is little potentially arable land available except for the acid-infertile grazing lands and rainforests of the tropics. Given these constraints on land resources, a global view of a sustainable agriculture must accommodate the need to double worldwide food production over a 50 year period. Thus, sustainable agricultural systems must intensify production on existing crop land to produce greater yields per unit land area.

Soil Fertility Research for a Sustainable Agriculture

The need to double global food output without a large increase in land under cultivation presents a formidable challenge. To achieve this goal, nutrient inputs to and outputs from existing farm land must increase accordingly because crop nutrient requirements are quite rigid. A two-fold yield increase will remove two-fold more nutrients at harvest. Cereal crops are likely to remain the foundation of the human food chain due to advantages over other crops in yield and storage, and because they are preferred as staples. With limited land and water resources, the relative importance of nitrogen (N) inputs from legumes and organic manures will decline. If this holds true, a sustainable agriculture will depend on management strategies that optimize crop uptake efficiency from N fertilizers and minimize nitrate leaching to groundwater.

At issue is whether a management strategy that mostly relies on fertilizer-N to alleviate crop N deficiency inherently leads to unacceptable levels of nitrate movement to groundwater. Although nitrate leaching is often presumed to be directly proportional to the level of N inputs, it is not at all clear that this holds true when N applications are split to better match crop demand, and proper rates, forms, and placement methods are used. To resolve this issue, researchers must not only consider yield response to applied N, but also N output/input efficiency and the potential for nitrate leaching when comparing N management strategies. Without sufficient field studies in which these performance parameters have been monitored concurrently over several cropping seasons, the cause and effect relationship between N input level and nitrate leaching will remain a crucial issue.

The flux of other essential nutrients through existing cropping systems must also increase. For phosphorus (P) and potassium (K), high-grade deposits of these nutrients occur in a few limited areas, and most countries must import these nutrients. Improved utilization efficiency of P and K will therefore increase in importance. Innovations in placement techniques that match nutrient availability with root distribution and available soil moisture for different crops and tillage strategies should receive greater attention. For all nutrients, a capacity to identify the soil nutrient status of each location in a field and apply variable nutrient rates to match site-specific needs may increase nutrient utilization efficiency significantly where land-leveling or topography make native soil fertility extremely variable.

The greatest challenge, however, is to undertand how soil fertility management affects soil quality, and to apply this knowledge to integrate all aspects of crop management to optimize yield and input utilization efficiency over the long term. Soil fertility management governs plant nutrition, which in turn influences susceptibility to disease, plant growth, and yield. Crop growth determines the quantity of root biomass and returned crop residues which are the organic matter inputs that determine soil organic carbon levels. Soil organic matter content is a key measure of soil quality because it influences all of the important physical, chemical, and biological soil properties that govern input utilization efficiency and potential productivity of a cropping system. Unfortunately, our basic understanding of these processes is very limited.

In their landmark work, *The Soil Under Shifting Cultivation*, published in 1960, Nye and Greenland concluded: "There is a general impression that continuous cropping leads to a lack of 'heart' in the soil. Though this is frequently ascribed to a fall in organic matter content, it is far from certain that it should be, nor is it known to what extent lack of 'heart' implies low yields. The question is complicated by the fact that poor yields due to low nutrient status may in themselves promote a poor physical condition because of poor cover, and low return of litter and root residues. Conversely, high yields induced by fertilizers may maintain an excellent constitution as shown for heavily fertilized soils growing maize continuously."

Of course, "heavy" fertilization is not likely to be an economic option, and the crucial issue remains unanswered: What are the fundamental processes that link soil fertility managment to changes in soil quality? A clear understanding of these mechanisms is a prerequisite for developing sustainable agricultural systems to meet the future food demand of a rapidly growing human population. ■

Managing Phosphorus for Enhanced and Sustained Agricultural Production

By Robert L. Fox

The concept that phosphate (P) fixation is the soil chemistry equivalent of a one-way street is so misleading that it should be abandoned. In fact, P fixed by soils apportions a limited P supply for the greatest advantage. Knowing how to use fixed P to our advantage makes it possible to help sustain and enhance agricultural production for long periods of time.

IF THERE IS ONE COMMON BOND among bonafide agriculturalists, it should be a disinterest in, or perhaps distrust of, production systems that promise no more than a sustainable agriculture. No one whose livelihood depends directly on crop production is satisfied with maintaining the status quo.

In fact, many farmers insist on pushing yields beyond maximum economic returns. Why should they do that? There are numerous reasons. Some of them may not make sense to a confirmed materialist, but some of them do make sense and should not be ignored.

(continued on next page)

Dr. Fox is Professor Emeritus, Department of Agronomy and Soil Science, University of Hawaii, Honolulu, HI.

Managing Phosphorus . . . from page 19

The reasons depend upon the input being considered. A good one, in the case of fertilizer P, is that long-term benefits from added P are greater than is generally believed. It is true that recovery of added P by the crop to which it was applied is seldom greater than 10 percent. Recovery by each succeeding crop is usually less. But it does not necessarily follow that if a nominal increment of P is inefficiently utilized, the next increment will be even less efficient. Such is predicted by the classical law of diminishing returns. Instead, there is a threshold concentration of P in the soil below which net nutrient uptake by plant roots stops.

In the region of the threshold, concentration absorption efficiency (P uptake per unit weight of roots per unit P concentration) approaches zero. Various schemes can be used to push the threshold concentration down, even to the limit of P detection: less demanding crops, more tolerant varieties, foliar feeding, localized fertilizer placement, etc. But rest assured, the threshold is still there.

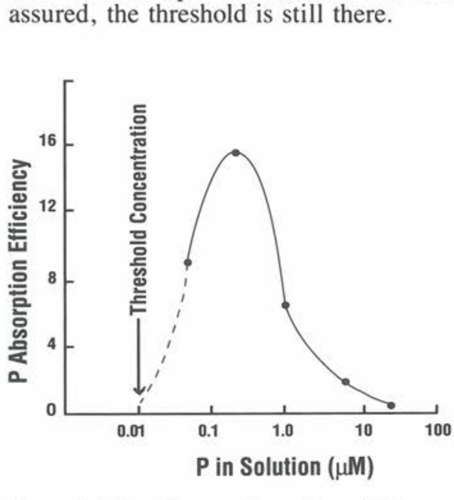


Figure 1. Phosphorus absorption efficiency by plant roots in relation to the concentration of P in the nutrient solution. In soils with P concentration near threshold, fertilization that does not substantially increase concentration will probably be inefficient use of the phosphate.

The Turks tell a story about a famous teacher who experimented with his donkey by feeding it less every day, expecting that eventually it would not require feed at all. The experiment went as planned for some days, but unfortunately the donkey died. Do we need to continually repeat the Nazri Din Hodja donkey experiment? We are dealing with matter more important than donkeys.

There is a saturation point above which adding more P does not increase uptake by plants. Above that point P absorption efficiency is also zero. An example of a P absorption efficiency curve that includes both threshold and saturation concentration is presented in **Figure 1**.

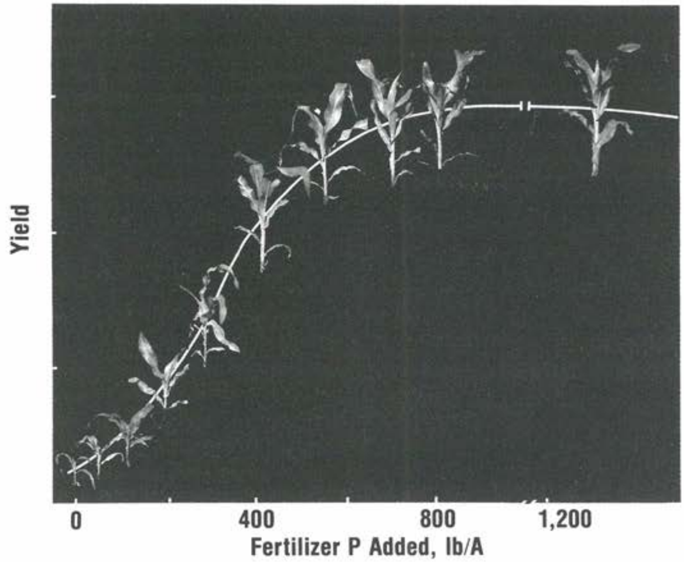
Most agriculture, conducted on land previously fertilized, operates at P concentrations greater than the threshold level. But such may not be the case in areas of highly weathered soils where a ''minimum inputs'' system has been practiced. To replace **minimum** inputs with **low** inputs will probably be inefficient use of resources until maximum P absorption efficiency is attained. **Figure 2** is an example of what happened when various rates of P were added to a very P deficient, bench-terraced (subsoil and topsoil mixed) oxisol. The response curve is not typical of the law of diminishing returns. It is sigmoid shaped. The first increments of P were less efficient than in the mid-range.

To recommend that an under-capitalized farmer operate at the low end of such a response curve would do him an economic injustice.

Too often, we assume that P fixation is the chemical equivalent of a one-way street—that fixed P is irretrievably lost as a plant nutrient. Such a concept is so deeply ingrained and so misleading that the term P fixation should be abandoned.

Consider the result of applying appropriate quantities of P to a highly P retentive soil in Hawaii. The P requirement was enormous, but when an appropriate fertilizer application was effected, production of forage was also enormous and

Figure 2.
A field example of P fertilizer inefficiency in the region of the threshold concentration.



continued so for several years. The quantity of fertilizer P utilized cannot be evaluated with precision. However, during the first eight years, the quantity of P removed in forage from the highest P treatments exceeded P removed in the no P control treatment equivalent to approximately 40 percent of that which had been added originally.

More recently, beginning 25 years after the plots were established and about 10 years after they reverted to open pasture, they were examined from several standpoints. Improved conditions favorable to enhanced agricultural production were noted in several respects. These included evidence of greater nitrogen (N) fixation by legumes, greater depth of biological activity, accumulation of organic P, decreased P adsorption (decreased requirement for fertilizer P), and a shift in the botanical composition of the sward. The effect of residual fertilizer P on the botanical composition is well documented. Twenty-six years after the P was applied, there is a distinction between fertilized and non-fertilized areas . . . a convincing argument for good P nutrition to promote sustainable agriculture.

In order to sustain themselves, grazing animals must discriminate between good and inferior nutrition in the forage they consume. These animals, given free choice, rejected the vegetation (mostly rat-tail grass, *Sporobolus capensis*) growing on soil that had not been fertilized with P. They grazed most heavily in plots that had been heavily fertilized 26 years before. The grazing pattern corresponded closely to plot boundaries—usually within 4 to 6 inches.

Summary

So far, "sustainability" is a catch phrase looking for a definition. The concept seems to be useful as the password that should accompany research proposals seeking extramural funding. But if it is to be useful in a practical way, the concept must include whatever technology may be necessary, not only to sustain productivity but to enhance it. In most areas of the world, enhanced productivity will require substantially increased inputs of one kind or another. Furthermore, the rate of enhancement should increase with time to match increasing demand for agriculture products from an ever-decreasing soil resource base. Thus it appears that for P fertilizer, at least, low-input sustainable agriculture is a contradiction of terms. It is not technically feasible for those situations that are in greatest need; and advocating such a system may be psychologically damaging because the slogan promises more than it can deliver. ■

Strategic Management of Agricultural Research

By Don Holt

Problems associated with overproduction of agricultural commodities are often attributed to research. From time to time, pressure is brought to bear to reduce production research, which is seen as contributing to surpluses, and increase utilization research, which promises to create and expand markets. Traditional production research, including soil fertility research, is also criticized for leading to wider use of chemicals and other purchased inputs, thus endangering the environment and increasing costs of production.

WHEN DISCUSSING RESEARCH STRATEGY, I often ask groups to pretend they are developing strategy for a large manufacturing firm named U.S. Farming, Inc., which is competing with other similar firms in an international market. This is not too great a stretch of the imagination, because production agriculture is organized not only at the farm level, but also at county, state, and national levels.

International agricultural competition is among states and nations, as well as among individual farmers. When state and national legislators and agency heads make agricultural research decisions, they play strategy-developing roles similar to corporate level managers in manufacturing firms.

Competition Is a Good Theme for Strategic Planning

The need to meet competition provides focus to research planning. As Ross Perot says, "When you have a gun to your head, it tends to focus your thinking." Private firms conduct research and development to help market products more competitively. They use a broad definition of marketing, recognizing that some marketing constraints, particularly those involving cost and quality, are removed by improving the production process.

Even people who are more concerned about environmental quality, conservation, or food safety than about agricultural profitability would be well-advised to develop agricultural research strategy within the conceptual framework of competition. After all, much of the new information and technology that will achieve their goals must ultimately be implemented by farmers and agribusiness people. If it cannot be implemented profitably, it will not be implemented.

Competitive business strategies fall into the categories of cost, differentiation, innovation, growth, and alliance. Diversification and vertical integration are growth strategies. Alliance strategies include joint venture, merger, and value-added partnerships, sometimes referred to as vertical cooperation.

The Cost of Producing Commodities Should Be Reduced

A business rule of thumb states that the basis of competition in a commodity market is cost of production. Since commodities, by definition, have about the same value over the whole market, differences in profitability arise from differences in cost of production.

Production systems research, including soil fertility research, provides information farmers use to reduce costs per unit of product marketed. Best management

Dr. Holt is Director, Illinois Agricultural Experiment Station, University of Illinois, Urbana-Champaign.

practices (BMPs) and maximum economic yield (MEY) are primarily cost reduction strategies and so play essential roles in achieving and maintaining competitiveness in commodity markets.

Of course, individual commodity producers must market their products wisely and make sure that market mechanisms provide incentives for improving quality, but they cannot afford to ignore cost of production. Private sector experience suggests that a commodity market lost is a commodity market lost forever.

When agricultural research decision-makers reduce or eliminate production research, they rule out cost-reduction as a strategy, a potentially disastrous error for commodity producers. Among other advantages to cost reduction as a strategy, 100 percent of cost savings accrue to the bottom line, whereas only a smaller percentage, the profit percentage, of increased sales finds its way to the bottom line.

Most proposed research programs in the commodity utilization area focus on developing innovative processing technology, so as to reduce processing costs. In many cases, however, the principle processing cost is the cost of raw material, namely the commodity crop. In those situations, research to improve the value or reduce the cost of the commodity for specific uses is probably the key to creating, expanding, or penetrating markets.

Can U.S. Farmers Achieve Differentiation in Commodity Markets?

If, through biotechnology or other approaches, new crops or crop varieties could be developed that would be especially valuable for specific uses, the first farmers to produce the new crops or varieties would capture niche markets, or, even more important, achieve differentiation in commodity markets. For example, U.S. farmers would benefit tremendously if they could achieve differentiation in the market for animal feed, which consumes well over half the corn and soybeans produced.

The problem with implementing this strategy is that the seed business, like the commodity-producing business, is international. The new, improved crop varieties will inevitably be marketed internationally. New varieties, pesticides, and other agricultural inputs will be available to other farmers as soon as they are to U.S. farmers. How can U.S. farmers, or the farmers of any other nation, be the early and most effective adopters of this new technology?

The Competitive Key Is Adaptive Research and Extension

Some years ago, I heard an excellent presentation on research management by Eliseu Alves, then President of EMBRAPA, the Brazilian equivalent of USDA. Afterwards, I asked him to describe the Brazilian agricultural research strategy. He explained that Brazil did not have the resources to conduct basic and early stage developmental research on the scale and scope of the United States or other developed nations. Therefore, he said, they will concentrate on creating an excellent research farm system and an excellent extension system.

With this improved institutional capacity for adaptive research and technology transfer, they will take new ideas coming out of worldwide basic research and new products being marketed all over the world by agribusiness firms, and adapt them as rapidly as possible to Brazilian agricultural conditions. They will achieve competitive advantage, he said, not by being the first to generate new ideas, new products, and new practices, but the first to employ them effectively and profitably in commercial agriculture.

Over the past century, the U.S. agriculture research and development system achieved scientific leadership and enabled U.S. farmers to achieve technological leadership. With clear objectives, sound strategy, and a well-supported research and development infrastructure, the U.S. can restore and maintain its leadership position. Production research, including soil fertility research, will be a key component of effective agricultural research strategy. ■

Soil Conservation Ethics

By D.A. Rennie

Many organizations have ethics, and often these include a dozen or more well thought out "motherhood" statements. In contrast, soil conservation ethics are relatively simple—they require adherence to facts. The majority of these are scientific facts, and it is most important that all of us in the business of supporting soil stewardship adhere to ethics of this nature or else farmers will be misled.

AS WE ENTER the last decade of the 20th century, concern for the environment is forcing a serious re-evaluation, by both the public and private sectors, of how we manage our soil, air and water.

This concern is heightened in the agricultural arena by an ever-increasing number of environmental groups who seek to restrict key and essential production inputs based on the mistaken concept that this would lead to higher quality food being produced, and a lowering in off-farm pollution. Conservation ethics demand that changes in production practices be based on sound scientific facts, not hopes or aspirations of well intentioned but misguided individuals.

Similarly in the semi-arid regions of North America, there is increasing concern about the impact of what many call the deadly legacy that we have inherited from our wasteful use of fossil fuels, the so-called "greenhouse effect." While there is no clear evidence that Saskatchewan's erratic weather has been influenced by the greenhouse effect, those who are brave enough to predict our future weather leave us with the vision of much of western Canada reverting to a desert. Such forecasts are in reality little more than hunches and are not supported by sound scientific evidence. Again, soil conservation ethics demand that the specter of "major climatic change" be relegated at this time to a science fiction category. This does not, however, mean that we should ignore possible climatic changes. It does mean that research should continue to prioritize drought-avoiding cropping systems and further that our current high dependence on summer fallowing must continue to be questioned.

Summer Fallowing

As recently as ten to fifteen years ago, it was rare to find an agronomist, agrologist, farmer or politician who agreed that the frequency of summer fallowing could be reduced without unacceptable risk of crop failure. However, almost without exception, there is today full concurrence with the statement that intensely tilled fallow is soil destructive. Fallow is generally recognized as being a singular cause of extensive soil erosion; it has accelerated the rapid loss of soil organic matter, has degraded the tilth and structure of the surface soil, and has been extremely inefficient in doing what it was designed to do, that of capturing precipitation for use in subsequent crop production.

Further, because fallow distorts the water cycle, it has to varying degrees contributed to an increasing acreage of salt-affected soils in Canada and the U.S.

While fallow acreage in Saskatchewan has declined from about 18 million acres to 14 or 15 million, this practice continues to be a rational economic decision on the part of farmers in part because economists don't include degradation in their cash flow budget. This continuing conflict between economics and soil stewardship is an integral part of the discussions and debate associated with conservation ethics, and the topic of *sustainable agricultural development*.

Dr. Rennie is Dean Emeritus, College of Agriculture, University of Saskatchewan. This article is adapted from a presentation during the L.B. Thompson Award Ceremonies, Melfort, SK, in April 1990.

CONSERVATION practices are recognized as a vital part of production agriculture for the future. This scene in western Canada depicts field shelterbelts, forages, strip cropping and crop rotation.

Photo credit: Agriculture Canada, Prairie Farm Rehabilitation Administration (PFRA)

Soil Conservation and Agricultural Sustainability

There is no doubt that in the 1990s soil conservation strategy will be equated with sustainable agriculture development. The latter term relates to a more holistic approach towards the stewardship of soil. A very wide range of definitions has been coined. In many of the concepts of sustainable agriculture, misinformation abounds. Soil conservation ethics require that farmers and policy makers become aware of the "pitfalls" associated with such catch phrases such as low-input sustainable agriculture (LISA) which has spread like a prairie fire.

LISA was born as a result of concern over possible deterioration in surface and groundwater quality, and suspected pesticide residues in food. The public perception is that the USDA's farm programs are encouraging, through billions of dollars spent on price support, the heavy and perhaps excess use of agricultural chemicals. Thus, the current public mood naturally supported any move to foster lower inputs which would reduce water pollution, preserve the soil and improve food quality through reducing chemical use.

Similar concerns have been voiced by consumers in western Canada, despite the fact that Canadian agricultural policy generally discouraged even optimum inputs of agricultural chemicals. In reality, for western Canadian farmers, LISA has to be categorized as misinformation. Any farmer who follows the various production processes prescribed by LISA would open the door to early bankruptcy.

Another new entry into the sustainable agriculture area is the term, *Alternative Agriculture*. A 450-page report prepared under the auspices of the U.S. National Research Council strongly urges agriculture throughout the U.S. to opt for farming techniques that include fewer off-farm chemical inputs, crop rotations to reduce the use of pesticides, and the adoption by farmers of what is termed "natural processes". **Again, while some of the guidelines contained in various alternative agriculture proposals may have limited merit for certain of North America's soil and climatic regions, this is not so in western Canada**. As a matter of fact, the alternative agriculture report includes a wide range of on-farm case studies. It is significant that while the report is targeted at all farmers in North America, none of the case studies took place in the semi-arid Great Plains region of North America, which includes all of the prairie provinces and extends as far south as the Texas panhandle.

Nitrogen Management

The addition of organic materials to the soil, whether it be crop residues, farm

(continued on next page)

Conservation Ethics . . . from page 25
manure or green manuring crops, provides key and essential sources of energy for soil organisms. However, the principals expounded by organic farming enthusiasts contradict many of the agricultural "facts of life." Even though an organic farmer sincerely believes that the N derived from decaying manure is much superior to N from a synthetic fertilizer, nothing can be further from the truth. Because of the precision with which we can (1) measure through soil test the optimum rate of N application and (2) apply this N at an opportune time, and (3) place the N fertilizer at an optimum position with respect to the growing crop, efficiency of crop use of fertilizer N can readily be maximized. This is not so with legume residues or farm manure. With good fertilizer management practices, losses of N by leaching or denitrification are sharply less than from organic sources.

The incidence of herbicide contamination of food is less than one or two contaminated in several millions tested. The claim by organic farmers that their product is residue-free holds little water. There is a very strong likelihood that history will duly record that the much acclaimed quality of organically produced food was one of the greatest hoaxes of the late 20th century. Organic farming under semi-arid conditions very frequently is soil destructive. As tillage is substituted for herbicides, accelerated breakdown of soil organic matter is favoured over organic matter build-up. Organic farmers rely on the mineralization of organic materials in the soil for their supply of many essential plant nutrients.

Ethics in Soil Conservation

Ethics in soil conservation requires an adherence to the truth based on scientific facts . . . not fiction, not hope, and not faith! Over much of the Prairie region of Canada and the Great Plains of the U.S., conservation ethics in the first instance means we must use water as efficiently as possible. A recently completed six-year study with some 40 farmers in Saskatchewan clearly underscores the fact that we can double and perhaps even triple the efficiency with which we use water to grow crops. Fortunately, the same water efficient components of our cropping system lessen dramatically the impact of soil degrading factors such as wind and water erosion, soil organic matter degradation and declines in the quality of the tilth of our surface soil.

In summary, good conservation ethics will lead to the successful conduct of sustainable farming throughout the Prairie and Great Plains. Not all the technology is in place today. But with efforts such as the Canadian National Soil Conservation Program and with greater federal, provincial and state government commitments to scientific agricultural research—focusing on factors such as water-efficient, soil conserving cropping systems—the sustainability of agriculture will certainly be advanced.

The first generation of farming on the Prairies has led to unacceptable destruction of soils. A new generation of farming technology is now available, and farmers can leverage their way into the 21st century with optimism. Farmers who continue to operate at 20th century knowledge levels are at high risk as are the soils on their farms. The 20th century concept that all have the right to be farmers will fall to the wayside. Farmers in the 21st century will be skilled managers, capable of sifting through an ever-expanding body of new farm technology and selecting only those components which will ensure the economic viability of farm operations, and at the same time guarantee high soil quality.■

International Canola Conference Proceedings Available

PROCEEDINGS OF THE 1990 International Canola Conference are available. The meeting April 2-5 in Atlanta, GA, was attended by more than 200 persons.

Copies of the Proceedings can be obtained by contacting: Dr. Noble Usherwood, PPI, 2801 Buford Hwy., N.E., Suite 401, Atlanta, GA 30329. Costs are $12 per copy in the U.S., $15 per copy in Canada and other countries. Checks should be made payable to "PPI".■

U.S. Fertilizer Use Efficiency near All-Time High

By G.W. Wallingford

Concern about groundwater and surface water contamination with nitrates has led to increased scrutiny of the use of commercial fertilizers. U.S. farmers are indeed using more commercial fertilizer now than they did 30 years ago. But the facts show that they have made major improvements in how efficiently they do it.

Corn Yields and Fertilizer Efficiency Up

AS SHOWN in **Figure 1,** corn yields in the U.S. have continued an upward trend since 1970 (see footnote). Even the droughts of 1983 and 1988 did not hold back the long-term trend toward higher yields.

There are many management factors determining yield, but providing adequate plant nutrients is essential. Fertilizer use increased on corn until the early 1980s, when the total pounds of fertilizer applied began a downward trend, also shown in **Figure 1**.

Fertilizer efficiency is the ratio of bushels produced to pounds of fertilizer applied. It can be improved by increasing the yield and/or reducing the amount of fertilizer applied.

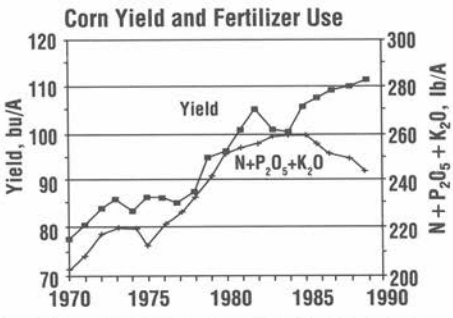


Figure 1. Average yields (bu/A) and fertilizer rates (lb/A) of $N+P_2O_5+K_2O$ for corn in the U.S.

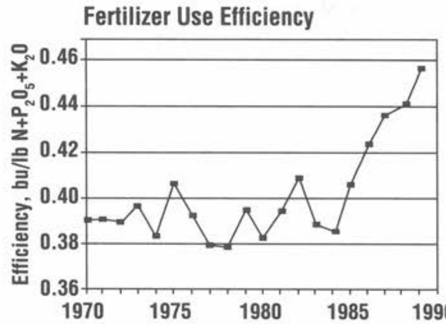


Figure 2. Fertilizer use efficiency of U.S. corn grain. Fertilizer use efficiency is the average corn yield (bu/A) in the U.S. divided by the total application rate (lb/A) of $N+P_2O_5+K_2O$.

The trend in **Figure 2** clearly shows that fertilizer efficiency is improving.

U.S. farmers in 1986, 1987 and 1989 produced more bushels of corn grain for every pound of fertilizer applied than at any time since the mid-1960s. This is a remarkable achievement considering corn yields have almost doubled since 1964 **(Table 1)**.

Nitrogen (N) Efficiency Up

Nitrogen use on corn generally increased until the mid-1980s and has declined since. Nitrogen use efficiency has

(continued on next page)

Note: The historical data shown in **Figures 1 to 6** are five-year running averages. The data cited for 1989, for example, are averages of the annual figures for 1989 and the four previous years. Using five-year running averages smooths out yearly variations and makes long-term trends easier to identify. **Table 1** contains the annual data from USDA.

Dr. Wallingford is Eastcentral Director of the Potash & Phosphate Institute (PPI), Columbus, OH.

Fertilizer Efficiency . . . from page 27

Table 1. U.S. corn yield and fertilizer use statistics from USDA. The yield data are for the entire U.S. while the fertilizer use data are based on surveys in the leading corn-producing states and extrapolated to the entire U.S. From 1981 to 1989 the states in the fertilizer use survey included IL, IN, IA, MI, MN, MO, NE, OH, SD and WI. These 10 states produced 84% of the total corn grain and had 83% of the corn acres in 1989. Prior to 1981, up to 26 corn-producing states were included in USDA's fertilizer use surveys.

	Corn	------ N ------		------ P_2O_5 ------		------ K_2O ------		--- $N+P_2O_5+K_2O$ ---	
	Yield	Applied	Efficiency	Applied	Efficiency	Applied	Efficiency	Applied	Efficiency
Year	bu/A	lb/A	bu/lb	lb/A	bu/lb	lb/A	bu/lb	lb/A	bu/lb
1964	63	49	1.28	32	1.97	25	2.52	106	0.59
1965	74	66	1.12	41	1.81	37	2.00	144	0.51
1966	73	78	0.94	49	1.49	46	1.59	173	0.42
1967	80	86	0.93	52	1.54	49	1.63	187	0.43
1968	80	96	0.83	57	1.39	55	1.45	208	0.38
1969	86	102	0.84	56	1.53	55	1.56	213	0.40
1970	72	105	0.69	64	1.13	61	1.19	230	0.31
1971	88	101	0.87	55	1.60	52	1.69	208	0.42
1972	97	110	0.88	59	1.64	59	1.64	228	0.43
1973	91	106	0.86	55	1.66	57	1.60	218	0.42
1974	72	97	0.74	54	1.33	61	1.18	212	0.34
1975	86	99	0.87	50	1.73	55	1.57	204	0.42
1976	88	123	0.71	60	1.47	66	1.33	249	0.35
1977	91	123	0.74	60	1.52	67	1.36	250	0.36
1978	101	120	0.84	59	1.71	65	1.55	244	0.41
1979	110	130	0.84	61	1.80	69	1.59	260	0.42
1980	91	125	0.73	57	1.60	70	1.30	252	0.36
1981	109	133	0.82	60	1.82	72	1.51	265	0.41
1982	113	131	0.86	57	1.99	72	1.57	260	0.44
1983	81	132	0.61	56	1.45	71	1.14	259	0.31
1984	107	134	0.80	57	1.87	71	1.50	262	0.41
1985	118	136	0.87	52	2.27	66	1.79	254	0.46
1986	119	125	0.95	51	2.34	61	1.96	237	0.50
1987	120	127	0.94	51	2.35	64	1.87	242	0.50
1988	85	133	0.64	55	1.54	66	1.28	254	0.33
1989	116	127	0.91	50	2.32	61	1.90	238	0.49

Source: USDA

improved significantly since 1984 (**Figures 3 and 4**).

In 1989, U.S. corn farmers averaged 116 bu/A using just 127 lb/A of N. This produced an efficiency ratio of 0.91 bu per pound of N applied. U.S. farmers have made substantial progress in improving N use efficiency since the mid-1960s. Since 1967, the ratio has only exceeded 0.9 in 1986, 1987 and 1989.

Farmers Are Adopting Best Management Practices (BMPs)

Lower N rates along with the production of higher yields has allowed U.S. farmers to significantly increase their efficiency of corn production in recent years. This is strong proof that BMPs are being widely adopted on U.S. farms and are helping to minimize the potential for off-farm losses of nutrients.

BMPs helping raise crop yields include early planting dates, improved hybrids, better weed and pest control, and higher, more uniform plant populations. Nitrogen efficiency has also been improved by BMPs which directly improve plant uptake or reduce losses from the soil. Examples include using split applications, sidedressing or fertigation, the use of nitrification inhib-

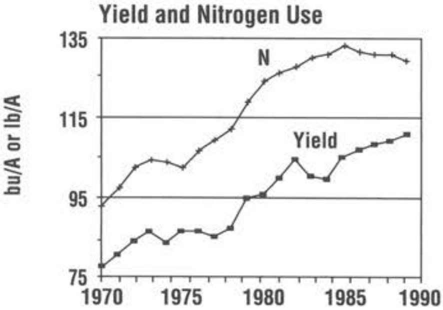


Figure 3. Average corn yields (bu/A) and N application rates (lb/A) on corn in the U.S.

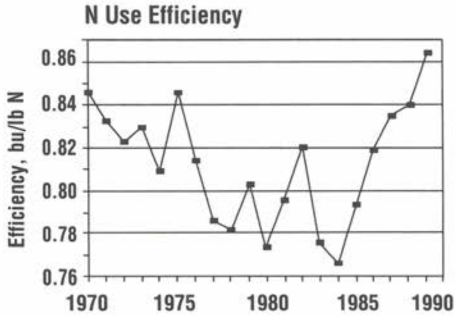


Figure 4. Nitrogen use efficiency of U.S. corn grain. Nitrogen use efficiency is the average corn yield (bu/A) in the U.S. divided by the application rate (lb/A) of N.

itors and careful matching of N rates with expected yield goals.

Phosphorus (P) and Potassium (K) Efficiency Up

Figure 5 shows that P and K use on corn generally began declining during the early and mid-1980s, respectively, while yields continued to increase. Unlike N, which must be applied to corn annually in most rotations used in the U.S., P and K needs can be satisfied either by direct application of commercial fertilizer or by allowing the crop to feed from residual supplies already in the soil.

U.S. farmers have been taking advantage of residual soil supplies which had been built up on some fields by previous fertilizer and manure applications. This showed up in the steady improvement in the efficiency of P and K use as illustrated in **Figure 6**.

Many U.S. soils have been depleted of P and K to the point where higher yields cannot be achieved without larger amounts being applied. Reports of visible nutrient deficiency symptoms, for example, became more common during the 1989 and 1990 growing seasons. Yields would have been even higher without this yield-limiting factor.

While many fields still have enough left in their "bank account" for continued depletion before plant growth problems occur, it is important that soils be tested regularly to avoid problems. It costs no more to maintain high soil test levels because eventually all of the P and K removed by harvested crops will have to be replaced. Higher soil test levels allow crops to take fuller advantage of better hybrids, optimum growing conditions, and improved management.

(continued on next page)

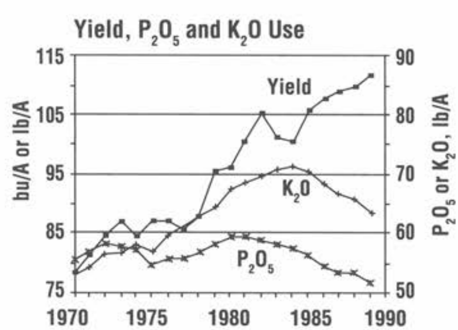


Figure 5. Average corn yields (bu/A) and P_2O_5 and K_2O application rates (lb/A) on corn in U.S.

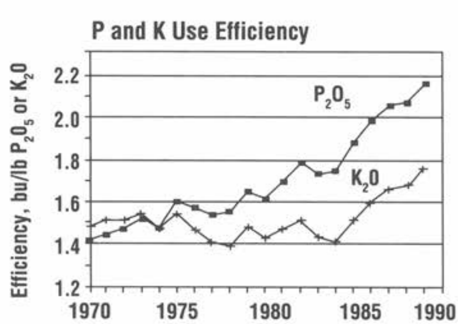


Figure 6. Use efficiency is the average corn yield (bu/A) in the U.S. divided by the application rate (lb/A) of P_2O_5 and K_2O.

Fertilizer Efficiency . . . from page 29

A critical question is: How much more can fertilizer-use efficiency be improved without hurting corn yields? While most efforts to improve efficiency are wise and should be encouraged, caution is needed.

Holding back gains in crop productivity may be a result of being too concerned with P and K fertilizer-use efficiency. Since the nutrient rate is often reduced when a farmer uses a more efficient application method, there is a smaller margin of error against losing yield from a nutrient shortage.

Higher rates provide insurance against poor weather conditions that even the best application method cannot overcome. Also, when an exceptionally good growing year comes along, the crop can use the extra nutrients to produce a higher and more profitable yield.

Current Trends Must Not Continue

The trends shown in **Figure 1** cannot continue. Either fertilizer use will have to increase or yields will start to decline due to inadequate nutrition.

In the long-term, farmers must supply the nutrients needed by their crops or yields and productivity will suffer. Without the improved efficiency which comes with higher yields, it will be difficult for the U.S. farmer to remain competitive.■

Dr. J.D. Beaton Named Fellow of Agriculture Institute of Canada


Dr. J.D. Beaton

DR. JAMES D. BEATON was named a Fellow of the Agricultural Institute of Canada (AIC) at the group's 70th annual meeting recently in British Columbia. Dr. Beaton is Senior Vice President for International Programs of the Potash & Phosphate Institute (PPI) and President of the Potash & Phosphate Institute of Canada (PPIC), located in Saskatoon, SK.

During his career, Dr. Beaton has served on numerous committees and through organizations relating to soil fertility. He is a co-author of the popular textbook, *Soil Fertility and Fertilizers*.

Dr. Beaton is a Fellow of the Canadian Society of Soil Science, of the Soil Science Society of America and of the American Society of Agronomy (ASA). He is also a recipient of the Agronomic Service Award of ASA and of the Agronomy Merit Award.

A British Columbia native, Dr. Beaton joined the PPI/PPIC staff in 1978.■

Dr. Marcus M. Alley Receives 1990 Robert E. Wagner Award for Efficient Agriculture

DR. MARCUS M. ALLEY, Professor of Agronomy at Virginia Tech, was named recipient of the Robert E. Wagner Award for Efficient Agriculture, presented at the 1990 American Society of Agronomy (ASA) annual meeting.

The award, supported by the Potash & Phosphate Institute (PPI) and administered by ASA, recognizes the importance of efficient and competitive agriculture. It is named for the retired president of PPI.

Dr. Alley has worked with development of an integrated management system for soft red winter wheat production. Specific wheat management projects have included row width and seeding rate studies, growth regulator experiments, and development of tissue testing for predicting wheat nitrogen (N) fertilizer requirements. Current efforts center on the use of soil and tissue testing to optimize N fertilizer efficiency in corn and wheat production.■

Dr. David W. Dibb Honored as Fellow of American Society of Agronomy


Dr. D.W. Dibb

DR. DAVID W. DIBB, President of the Potash & Phosphate Institute (PPI), has been selected as a Fellow of the American Society of Agronomy (ASA). He was honored at the 1990 ASA meetings in San Antonio.

ASA has been electing outstanding members to the position of Fellow since 1924. Nomination is based on professional achievements and meritorious service. Only 0.3 percent of the members may be elected Fellows.

Dr. Dibb holds degrees from Brigham Young University and the University of Illinois. He became President of PPI in January 1989 after serving in various other responsibilities with Institute programs in the U.S. and internationally. ■

Dr. Noble R. Usherwood Receives ASA Industrial Agronomists Award


Dr. N.R. Usherwood

DR. NOBLE R. USHERWOOD, Vice President of the Potash & Phosphate Institute (PPI), received the Industrial Agronomists Award at the 1990 annual meetings of the American Society of Agronomy (ASA).

The award is given to a productive, capable individual known for original and significant research and for an outstanding ability to inspire in students and associates the qualities of sound thinking, objectivity, integrity, and cooperation.

At PPI, Dr. Usherwood is responsible for Institute member services and for agronomic research and education programs in the Southeast region. ■

In Memory of H.L. Garrard, 1900-1990


H.L. Garrard

HERBERT L. GARRARD, a well-known agronomist and agricultural photographer, passed away Aug. 21, 1990 in Noblesville, IN. He is survived by his wife, Mary Margaret; two daughters, Flora Richard and Mary Grepp; a son, Bruce; and a grandchild. Mr. Garrard would have been 90 years of age Aug. 31.

An agronomist with the American Potash Institute (forerunner of the Potash & Phosphate Institute) from its beginning in 1935, Mr. Garrard also worked for N.V. Potash Export My., Inc. from 1927-35.

He was born in Muncie, IN, and earned B.S. and M.S. degrees at Purdue University. He held membership in numerous honorary societies and scientific organizations, including Alpha Zeta and the American Society of Agronomy.

During his work with the Institute, Mr. Garrard traveled over the Midwest working with university, industry and others. He encouraged soil testing, tissue testing, check plots and other techniques to demonstrate nutrient needs in crops. Mr. Garrard described himself as a "hard-boiled scientist and diagnostician."

Following retirement in 1965, he continued his work with agricultural photography, and was active with family, church and community interests for many years. ■

Agriculture—The Great Profession

A fine life—but must one be poor to be happy?

My children and grandchildren snickered each time I tried to interest them in a career in agriculture. No way! They wanted more prestige—bigger financial rewards. One grandchild—law graduate—started at $62,000. Another, a business major, makes even more. What they contribute is not the issue.

Enrollment in ag colleges is floundering. Students see farmers work hard and just eke out a living—while the media depict the rich farmer gouging the country for billions each year in subsidies.

What they don't see is the tremendous job that agriculture does for the world. Untold is the story of the modest, unappreciated, industrious farmer who contributes so much to society and to the environment.

The remarkable fact that just 2 percent of our population is required to grow our food only gives farmers less and less voice in the nation's affairs. The farmer himself fails to tell the public that American consumers spend 11 percent of their disposable income for food—while China spends 50 percent, and the developing nations spend 70 to 90 percent. With the money and time left over after getting their food, Americans can buy and do other things.

Agriculture is the most important and least appreciated of all professions—a fascinating, intriguing and satisfying life. Farmers are not a parasitic, environment-destroying group. But it is up to farmers themselves to recognize their contributions, and to convince others how important they are in today's complex world.

— J. Fielding Reed

Better Crops
WITH PLANT FOOD
Potash & Phosphate Institute
Suite 401, 2801 Buford Hwy., N.E., Atlanta, GA 30329

BULK RATE
U. S. POSTAGE
PAID
Atlanta, GA 30329
Permit No. 1355