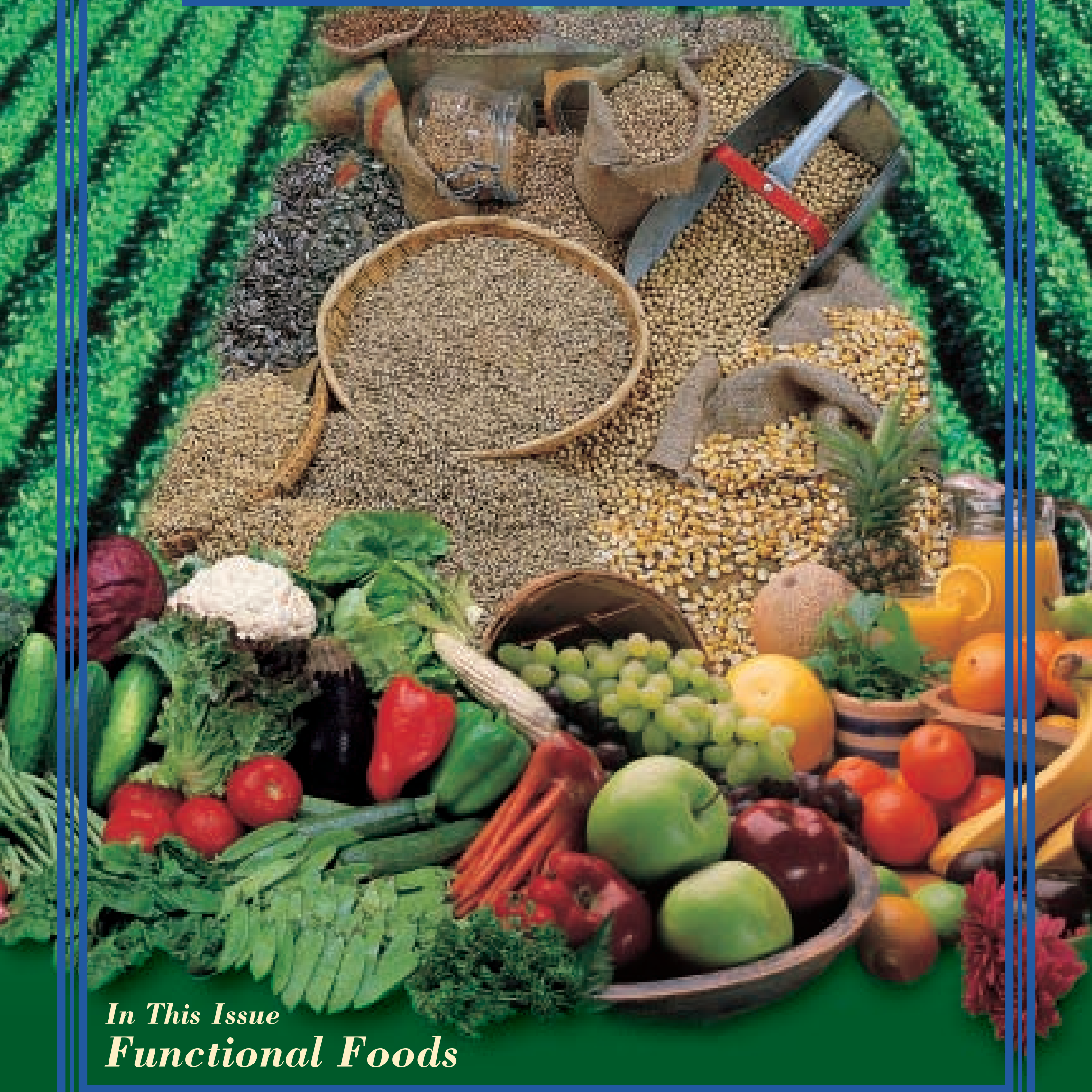
BETTER CROPS
WITH PLANT FOOD

2000 Number 2



In This Issue
Functional Foods

BETTER CROPS
WITH PLANT FOOD

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Helping Farmers Produce More and Healthier Food

Can research unlock the door to increased crop yields and foods that enhance human health and fitness? Scientists at PPI/PPIC and the Foundation for Agronomic Research (FAR) think there are opportunities to do just that...manage crop production for higher yields and better food quality. To that end, PPI/PPIC and FAR announce two new research initiatives: ***Narrowing the Yield Gap with Knowledge and Technology*** and ***Managing Crop Production for End-Use Quality***. These initiatives provide the opportunity to assemble a coalition of North American stakeholders to support cropping systems research that exceeds individual interests and abilities.

Narrowing the Yield Gap with Knowledge and Technology – The previous issue of *Better Crops with Plant Food* (2000, No. 1) reviewed and documented the tremendous yield potential in North American agriculture. There is a huge gap between attainable crop yields and yields normally harvested. The challenge is to sort out management factors that must be implemented to narrow this gap. This initiative hopes to define:

- attainable yields in different environments using the latest genetics, cultural practices, and technologies
- a reproducible framework for growing high yields for specific cropping systems, while protecting the environment
- the role of phosphorus (P), potassium (K), and other inputs and practices (e.g. tillage systems, crop rotations, hybrids, plant population, pest management strategy, etc.) in high yield environments.

The target audiences of this initiative include: farmers who need higher yields to spread their fixed costs over more units of production, agribusiness firms needing to know how to place their products into systems that offer the greatest potential benefits to the producer and environment, site-specific precision practitioners who need to know how to combine input and management practices, and governments and institutions defining acceptable criteria for nutrient management plans.

Managing Crop Production for End-Use Quality – This issue of *Better Crops with Plant Food* includes two articles on crop quality and "functional" or "designer" foods that contain bio-active ingredients, or phytochemicals, believed to enhance human health and fitness and that may be manipulated through agronomic management. The growing demand by health-conscious consumers is driving a billion dollar market that producers cannot afford to ignore.

Functional foods are associated with the prevention and treatment of disease and other medical ailments. The opportunities for biotechnology to genetically augment phytochemicals in crops are great, but genetics alone won't optimize functional food components. Agronomic practices and weather can have a big impact, and plant nutrition cannot be ignored.

This initiative will integrate with the ***Narrowing the Yield Gap with Knowledge and Technology*** initiative and study the quality impacts of crop management on functional food phytochemicals. It is designed to take advantage of consumer interest and new developments in biotechnology to help farmers produce healthier foods and provide convincing information to consumers that foods produced by intensive agriculture are of high nutritional quality.

Additional information on both initiatives is available from FAR, any PPI/PPIC office, or at **www.ppi-far.org**. BC

Functional Food Components: A Role for Mineral Nutrients?

By T.W. Bruulsema

Functional foods are defined as foods that contain bio-active ingredients thought to enhance health and fitness. The active ingredients are phytochemicals, such as lycopene in tomatoes, allicin in garlic, or isoflavones in soybeans (**Table 1**). These phytochemicals, also called "nutraceuticals", may be extracted and consumed as supplements, or may have therapeutic value when consumed in whole food.

Consumer interest in healthy food is expanding rapidly, particularly as the "baby boom" generation ages. The new concept of "functional food" gives a fresh perspective to the mineral nutrition of plants.

Functional food ingredients are associated with the prevention and treatment of several leading causes of death: cancer, diabetes, hypertension, and heart disease. In addition, some help with other medical ailments including neural tube defects, osteoporosis, abnormal bowel function, and arthritis. Their modes of action are diverse.

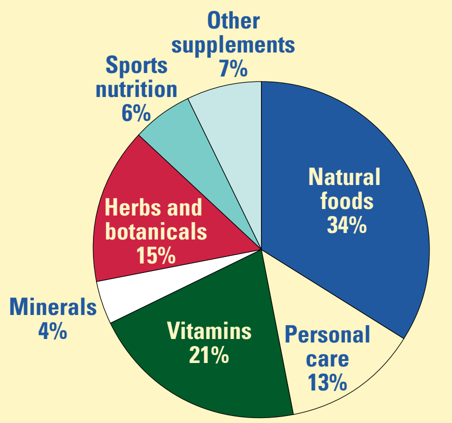

Figure 1. The $25.8 billion U.S. Nutrition Industry, 1998. (Source: *Nutrition Business Journal* Vol. 4 No. 6).

The functional food industry is considered to have tremendous potential for market growth. In the U.S. alone, sales of dietary supplements, herbs and botanicals, natural foods, and personal care products amounted to $25.8 billion in 1998.

The components of this industry are shown in **Figure 1**. In Japan, functional foods are regulated as "Foods for Specified Health Use" (FOSHU). Over 154 products are already registered as FOSHU, and their sales in Japan amount to $1.5 billion annually.

The fastest growing category of dietary supplements in 1998 was herbs and botanicals, with sales increasing 18 percent over 1997 levels. Their prospects for future growth are even higher. Why? When science can determine the phytochemicals that truly promote health, their use can be justified on a measurable basis. However, future medical and nutritional research will need to sort out many claims for potential functional food ingredients.

Food and feed crops that are enhanced in nutritional or nutraceutical content offer opportunity to almost every crop producer. While most of the attention is paid to food crops, the benefits to animal feeds may be equally valid. One study at Iowa State University indicated that isoflavones may enhance swine carcass muscle percentage. Thus, the discoveries in this new area of science have potential to impact the definitions

TABLE 1. Examples of functional foods and their active phytochemical ingredients.	
Functional food	**Nutraceutical ingredients**
Broccoli, cabbage, cauliflower	sulphoraphanes, indoles, carotenoids
Cranberries	quinic acid
Echinacea angustifolia	echinacosides, polysaccharides
Flax	lignans
Garlic	allicin, flavonoids, organosulfur compounds
Ginseng	more than 30 ginsenosides
Red grapes, red wine	resveratrol, quercitin, anthocyanidins
Soybean	isoflavones, saponins
Tomato	lycopene, carotenoids
Whole grains (oats, wheat, barley)	beta-glucans, saponins, terpenoids, phytic acid

of quality in both animal and human nutrition.

While functional food components are controlled strongly by genetics, other important factors include crop cultural practices, nutrient management, and weather. Plant metabolism of secondary phytochemicals is anabolic and energy-consuming. Thus, one might expect that well nourished plants would be more capable of producing phytochemicals. One example is a study that showed potassium (K) enhanced the lycopene content of tomatoes by 67 percent.

However, some phytochemicals are produced in response to stress conditions and might actually be enhanced under nutrient deprivation or adverse weather conditions. Finding the nature of these plant responses is an important agronomic research priority. Levels of fertility considered optimal for yield could be either suboptimal or excessive for optimum nutraceutical content.

How will the exciting changes in the food retail market impact the traditional agronomy of corn, wheat and soybeans? We can expect that future quality standards for many commodity crops will be influenced by new knowledge of nutraceuticals. The quality standards will become more complex than simple measures of test weight, crude protein, oil content, etc.

Potassium may enhance the lycopene content of tomatoes. Lycopene is a phytochemical with known health benefits.

Many quality traits are indeed impacted by the weather. It is uncertain whether identity-preserved contract production will be successful in providing grains with targeted standards for functional food components. However, premiums may be offered even on commodity crops that meet measurable standards. This will lead growers to manage variety selection, nutrient inputs, and other cultural practices to maximize chances of meeting standards for the quality components of interest.

The improvement of food quality is an important priority for agriculture. Deficiencies of trace minerals [iron (Fe), zinc (Zn), iodine (I), and selenium (Se)] and vitamin A currently affect more than two billion people worldwide. Enhancing the nutritional value of foods is not only a market opportunity, it meets real human needs.

Research on the role of soil fertility has much to discover about myriad crop phytochemicals and nutritive minerals. Soil fertility specialists must pay particular attention to developments that enhance mineral uptake in plants and their content of beneficial phytochemicals. BC

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Functional Food Components: A Role for Potassium?

By T.W. Bruulsema, C.J.C. Jackson, I. Rajcan, and T.J. Vyn

The functional food components in soybeans which are regarded as having important beneficial effects on human health include isoflavones such as genistein, daidzein, glycitein, and their respective glucosides. These phytochemicals are thought to be responsible for the reduced rates of cancer, heart disease, menopausal symptoms, and osteoporosis observed in people who regularly consume soybeans and soy foods.

> Field trials in two consecutive years in Ontario indicate that when soybean yields respond to potassium (K), isoflavone levels also increase.

Isoflavone levels in soybeans vary by more than threefold depending on variety and growing conditions. Our objective was to determine whether soil fertility contributes to this variation.

Soybeans grown at various levels of fertility in seven Ontario field trials were analyzed for total isoflavone content. Two of these trials involved a K fertilizer variable, and the others included various levels of lime and other nutrients added to the soil. Sites ranged from low to very high [35 to 190 parts per million (ppm)] in soil test K and medium to very high (13 to 60 ppm) in Olsen soil test phosphorus (P).

There are 12 isoflavones in soybeans, consisting of three aglycones (daidzein, genistein, and glycitein), their glycosides, and their corresponding acetyl and malonyl derivatives. The results of the total isoflavone concentration presented here have been normalized to three aglycones. Thus the overall levels of isoflavones may appear to be lower than those in other reports. The molecular weight (MW) of aglycone is about 54 percent of the MW of the glycoside forms.

At a site near Paris, Ontario, we compared soybeans with and without muriate of potash (MOP) fertilizer applied in bands 15 inches apart and about 3 inches deep. This trial was conducted in both 1998 and 1999. The soil test K (ammonium acetate extractable) in the top 6 inches was about 35 ppm.

Soybean yield and all three of the major isoflavone compounds showed a definite positive response to added K (**Table 1**). It is not known whether K plays a specific role in isoflavone synthesis, but it may, since K is an important enzyme cofactor for many plant metabolic reactions. It is possible that the reason for the observed effect was that K stimulated plant growth, since yields

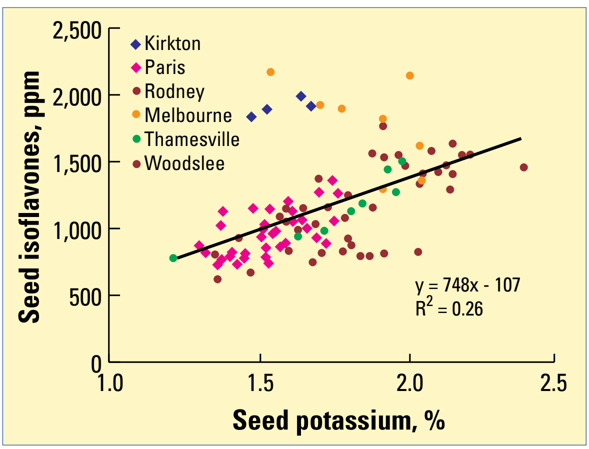

Figure 1. Isoflavone levels in soybeans from six Ontario sites in relation to soybean K content at harvest in 1998.

were also boosted by K.

Across six sites in 1998, there was a significant positive correlation between seed K and isoflavone concentrations in the harvested soybeans (**Figure 1**). There was also substantial variability between different sites and varieties, but since each variety was grown at a separate site, the effect of location could not be separated from the effect of variety.

TABLE 1. Band-applied K fertilizer boosted soybean yield and isoflavone content in a field at Paris, Ontario. Mean of two years, 1998-99, and three soybean row widths (7.5, 15 and 30 inches).

	Isoflavones, ppm				Yield,
K fertilizer rate	Genistein	Daidzein	Glycitein	Total	bu/A
90 lb K_2O/A banded	688	579	122	1,389	37.4
No K	537	499	109	1,145	31.8
Difference	28%	16%	12%	21%	17%

The positive correlation indicates that K could be one of the important factors controlling isoflavone levels. In a subset of the data comprising about half of the samples, the positive correlation with K was maintained even though there was no relationship of isoflavone levels with seed P. The reason for the lack of association with seed P may be that there was less variation in soil P fertility, or that there was less involvement of P in controlling isoflavone levels.

Across these sites, there was also an independent positive relationship between yield and isoflavone concentration (**Figure 2**). There was no significant correlation between yield and seed K.

The significant and positive correlation of isoflavone levels with yield is very encouraging, as it suggests that high yield is compatible with quality from a functional food perspective. Indeed, further research in this area may supply convincing information to consumers that modern high-yield agriculture can produce high quality food, rather than the "empty calories" that many perceive to be associated with high intensity production.

These observations reveal a significant role of plant mineral nutrition in the control of phytochemical levels in soybeans. This opens up a huge research opportunity to explore impacts of plant nutrition on a host of crop phytochemicals. In addition, this work implies that the introduction of crop varieties that are genetically enhanced in their functional food components may call for changes in the management of soil fertility in order to maximize their expression. BC

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Acknowledgments *– We thank Mr. D. Young and Dr. J. Omielan for providing soybean samples from several of the sites. Financial support for the field trials from Ontario Soybean Growers, Agriculture and Agri-Food Canada through the Agricultural Adaptation Council's CanAdapt Program, First Line Seeds Ltd., Canadian Fertilizer Institute, and Ontario Agri Business Association is also greatly appreciated.*

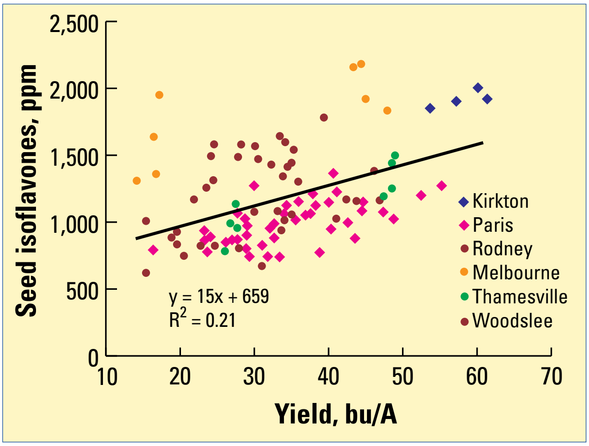

Figure 2. Isoflavone levels in soybeans from six Ontario sites in relation to soybean yield in 1998.

K A N S A S

Wheat Yield Modeling: How Important Is Soil Test Phosphorus?

By T.L. Kastens, K.C Dhuyvetter, J.P. Schmidt, and W.M. Stewart

Crop response to fertilizer nutrients such as P and potassium (K) is commonly predicted using soil test information. Fertilizer recommendations from soil tests are usually based on calibration curves. These curves are made by comparing yield of a specific crop at a specific soil test level to yield where the nutrient in question is not limiting. When these yield observations are made in many locations with different soil test levels, a calibration curve is developed where relative yield is plotted against soil test level. A common characteristic among calibration curves is that decreasing soil test level results in decreasing relative yield.

A unique approach to describing the relationship between yield and phosphorus (P) fertility has been developed by economists and agronomists at Kansas State University. This approach uses farm level information to estimate a function, or mathematical expression, for yield.

Crop yield at a given location and time is dependent on several variables. The objective of the mathematical modeling approach used in this research was to predict yield with specific levels of selected variables, such as nitrogen (N) and P fertilization rates. Developing a reliable yield function is a four-step process. First, variables thought to be the most important in affecting yield are selected. Second, data are collected from either planned experiments or from farm level information. The final steps involve selecting a specification for the function (linear, quadratic, etc.) and estimating parameter values to maximize accuracy of the predictions.

Detailed information from a farming operation in northwest Kansas (Rawlins

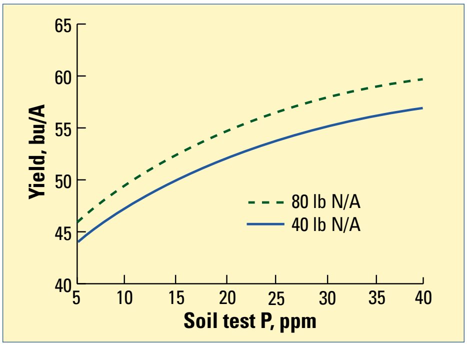

Figure 1. Relationship between field soil test P and predicted field wheat yield for two levels of N fertilization and no P fertilization. All other variables were kept at average values.

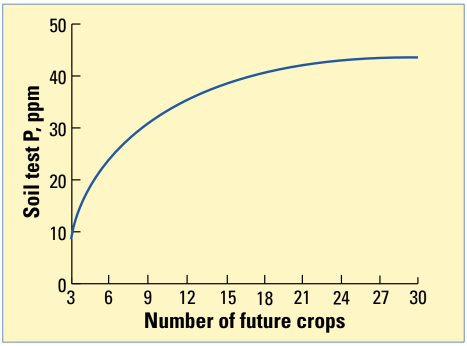

Figure 2. Most profitable steady state soil test P level by number of future wheat crops anticipated. Assumes that soil P level is built in the first year and maintained with yearly applications thereafter.

County) was used to produce a model that estimates dryland wheat yield for the farm. Data were collected from 1994 to 1999. The number of records (crop fields) by year were 1994 (17), 1995 (17), 1996 (13), 1997 (10), 1998 (20), and 1999 (15). For each year and field, average wheat yield, preplant soil test N and P, N and P fertilizer rates, soil organic matter, soil pH, and soil texture were measured. An expression was also added that accounted for the effects of late frost on yield.

The modified asymptotic mathematical function chosen for the yield model captured the following characteristics: 1) plateau-type convergence where predicted yields flatten out over broad levels of high inputs; 2) a "limiting-factor" framework, where no factor can fully compensate for the lack of another; 3) some factors, such as fertilizer P and soil test P, must behave as substitutes; and 4) some variables, such as soil pH, are allowed to peak mid-range rather than at endpoints. The R^2 value of the estimated model was 0.40.

Interestingly, the model showed that fertilizer P had little effect on wheat yield; however, soil test P had a substantial effect (**Figure 1**). This required that thinking and decisions be turned to increasing soil test P to optimum levels. Therefore, the influence of fertilizer P on soil test P had to be defined. The following assumptions were made: wheat removes 0.6 lb P_2O_5/bu, fertilizer P in excess of crop removal results in build-up of soil P, and that for each 15 lb P_2O_5/A applied above crop removal, soil test P (Bray-1 P) increases by one part per million (ppm).

Several simulations using the yield model were performed. Soil test information from four different data sets collected on the study farm was used. These included the model estimation data set, another field-level data set, and two grid-sampled fields. Profits calculated from the yield simulations were based on \$3.30/bu wheat, \$0.18/lb N, and \$0.27/lb P_2O_5. Since soil P had a substantial effect on yield, an important question that was addressed was: "What is the most profitable steady state soil test P level for different periods of production or land tenure?" The results indicate that as the anticipated number of crops increases, the optimum soil test P level increases in an asymptotic fashion (**Figure 2**). Where land is owned, an unlimited number of crops might be anticipated. The profit maximizing soil test level in this scenario is about 46 ppm (high, Bray-1 P). On the other hand, if land tenure is expected to be only five years, the optimal soil test P is about 21 ppm (medium, Bray-1 P). This analysis assumes that enough P fertilizer is applied in the first year to increase soil P to the optimum level, and that the level is maintained (steady state) by yearly maintenance applications.

In another simulation, this time on 10 crops, the steady state, or build and maintain, approach was compared to whatever P

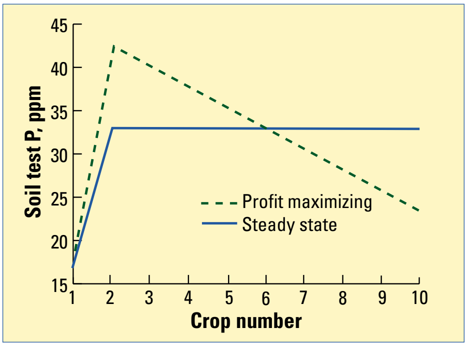

Figure 3. Most profitable steady state soil P level compared to the profit maximizing program for 10 wheat crops. The steady state scenario assumes that soil P level is built in the first year and maintained with yearly applications thereafter.

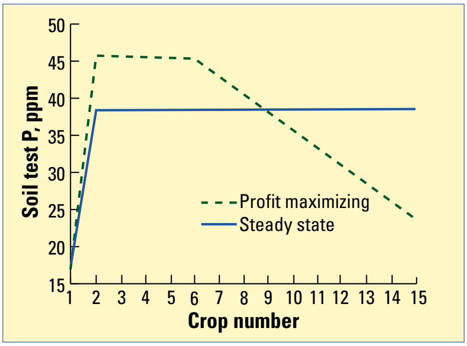

Figure 4. Most profitable steady state soil test P level compared to the profit maximizing program for 15 wheat crops. The steady state scenario assumes that soil P level is built in the first year and maintained with yearly applications thereafter.

fertilizer program the model determined to be profit maximizing (**Figure 3**). The model determined that optimum P fertilization with the build and maintain approach was to apply 279 lb P_2O_5/A the first year followed by 35.7 lb P_2O_5 for each following crop. This resulted in a per-crop average of 60 lb P_2O_5/A. The profit maximizing decision, however, was to apply 423 lb P_2O_5/A the first year, followed by no P_2O_5 for each following crop, for a per-crop average of only 42.3 lb P_2O_5/A. This is due to the responsiveness of yield to soil test P and not to fertilizer P estimated in the model. Although average soil test P over the 10 crops was virtually equal for the two scenarios, the profit maximizing approach was estimated to be $4.77/A per crop more profitable than the steady state approach. Simulations at longer land tenures showed that the advantage to the profit maximizing approach over the steady state approach diminishes, declining to 0 at an infinite number of crops. For example, at 15 crops, the advantage was $3.13/A per crop (**Figure 4**).

Crop production is affected by many biological, chemical, and physical factors. Any effort at predicting yield will have weaknesses because of the diversity and dynamic nature of the system. Nevertheless, some variables are more important in determining yield than others. For years, research has shown that P fertility is one of the important factors affecting yield. The modeling approach used in this research has further demonstrated the importance of soil test P in maximizing profit in wheat production. Although this research showed benefits to very large initial applications of P fertilizer, followed by a period of mining soil P in the last years of a land tenure, the steady state approach is less risky. That is, for farmers who found they incorrectly estimated land tenure on either the short or the long side, the steady state, or build and maintain approach would likely be the most profitable. Regardless, except for very short land tenures, recommendations were to build and maintain soil test P to the high level to maximize profitability and ensure the long-term sustainability of crop production.

This research represents a non-traditional approach to evaluating and predicting influences on yield that uses field level instead of small plot information. This technique of mathematical modeling, not to be confused with crop growth modeling, uses field level crop yield and fertility data to generate response functions that are used to guide fertilizer management decisions. It showed yield benefits to higher levels of soil P than would be expected from previous calibration research. Nevertheless, the production paradigm shift that is being brought about by site-specific management technologies suggests that this approach merits consideration. More investigation in the area of mathematical yield modeling is needed; therefore, this work should be considered exploratory and caution should be exercised in extrapolating from the specific results of this analysis. BC

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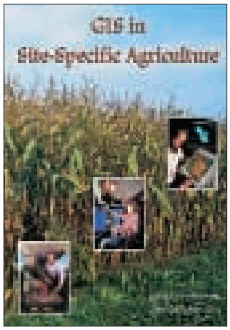
You can reach the Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC), and Foundation for Agronomic Research (FAR) on-line. Use one of the following as a URL to reach the web site: **www.ppi-ppic.org** or **www.ppi-far.org**.

There is increasing variety and diversity of information now available in electronic form at PPI/PPIC/FAR, with more additions and changes to the website coming soon. Current and back issues of *Better Crops with Plant Food*, *Better Crops International*, *News & Views*, and other publications are available as pdf files.

For further information, contact PPI headquarters by phone at (770) 447-0335 or fax, (770) 448-0439. BC

GIS in Site-Specific Agriculture – New Booklet Now Available

A new color booklet titled *GIS in Site-Specific Agriculture* introduces producers, agribusinesses, and students to the application of geographic information systems (GIS) technologies in the future management of the farm. Sample data representing a Midwest corn and soybean farm are used to explore simple spatial transformations and analyses using commercial off-the-shelf GIS software. Although corn and soybean data are used, the booklet provides an excellent general introduction to the role of GIS in site-specific agriculture.



The goal of site-specific farming is to treat small plots of land uniquely to realize the profit-yielding potential based on each plot's combination of soil, topography, nutrient, and moisture-regime characteristics. The application of site-specific farming is rapidly expanding. All components of production agriculture are expanding their capacity to support and apply site-specific agriculture techniques. *GIS in Site-Specific Agriculture* introduces managers to these new principles and the techniques used to successfully apply them.

Authors of the booklet are Dr. James D. Westervelt of the University of Illinois and Dr. Harold F. Reetz, Jr. of PPI. *GIS in Site-Specific Agriculture* contains 64 pages, presented as a 7 x 10-inch softbound publication (ISBN 0-8134-3193-X). It is available at an introductory price of $10.00 each (plus shipping/handling). Contact Interstate Publishers, Inc., P.O. Box 50, Danville, IL 61834-0050. Phone (217) 446-0500 or (800) 843-4774; fax (217) 446-9706; e-mail: info-ipp@IPPINC.com.

Research Notes

Missouri: On-Farm Starter Fertilizer Response in No-Till Corn

This three-year, on-farm study placed at six locations compared corn yield with no starter to three different starter treatments, each placed 2 inches beside and 2 inches below the seed. Starter categories included:

- Low nitrogen (N)/high phosphorus (P)...traditional...starter
- Medium N/medium P starter
- N-only starter

Starter fertilizer gave significant yield increases at all six locations. Responses ranged from 9 to 26 bu/A, with an average increase of 13 bu/A. There were no differences in yield among the starter categories when averaged across all six experiments. The N-only starter was the most profitable because it had the lowest material cost. However, at the two locations where soil test P was low, P-containing starter was slightly more profitable than the N-only starter.

Source: Scharf, P.C. 1999. On-Farm Starter Fertilizer Response in No-Till Corn. J. Prod. Agri. 12(4):692-695.

J. Fielding Reed PPI Fellowships Awarded to Five Graduate Students

Five outstanding graduate students have been announced as the 2000 winners of the "J. Fielding Reed PPI Fellowship" awards by the Potash & Phosphate Institute (PPI). Grants of $2,000 each are presented to the individuals. All are candidates for either the Master of Science (M.S.) or the Doctor of Philosophy (Ph.D.) degree in soil fertility and related fields.

Since the program began in 1980, 125 students have now received the Fellowships. The five winners for the year 2000 are:

- **Mr. Xinhua Yin,**
  Purdue University, West Lafayette, Indiana
- **Ms. Carrie A.M. Laboski,**
  University of Minnesota, St. Paul
- **Mr. R. Andrew Schofield,**
  University of Guelph, Ontario
- **Ms. Eugenia M. Pena-Yewtukhiw,**
  University of Kentucky
- **Mr. Mark L. Bernards,**
  Brigham Young University, Provo, Utah

"Each year, we are impressed with the quality of the applicants for this award, which recognizes and encourages an excellent group of graduate students in agronomic sciences," said Dr. David W. Dibb, President of PPI.

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

Scholastic record, leadership, and excellence in original research are among the important criteria evaluated for the Fellowships. Following is a brief summary of information for each of the year 2000 recipients.

Xinhua Yin was born in Hunan province, China. He received his B.S. degree at Hunan Agricultural University in 1985 and his M.S. degree from Nanjing Agricultural University in 1988. He was employed by Hunan Academy of Agricultural Sciences in China from 1988 to 1997. He began study toward his Ph.D. degree at the University of Guelph in the fall of 1997 and is currently in a doctoral program at Purdue University. Mr. Yin has been the recipient of many awards and honors during his academic career. His major professor says, "Xinhua Yin simply rates among the best Ph.D. graduate students in agriculture in North America." Mr. Yin is conducting research on 'Potassium Fertility Management for Soybeans in Conservation Tillage Systems,' with particular emphasis on no-till soybean yield and seed quality responses to potassium fertilizer placement directly preceding soybean planting, or for corn preceding soybeans. Following graduate school, he plans a career in research or Extension.

Carrie A.M. Laboski is a native of Lake Winola, Pennsylvania. She received her B.S. degree from Penn State University in 1993 and her M.S. degree from the University of Minnesota in 1995. She is currently studying for her Ph.D. degree, also at the University of Minnesota. Among other awards and honors, Ms. Laboski was the recipient of the American Society of Agronomy Outstanding Student Award in 1993 and the Harry J. Larsen/Hydro Memorial Scholarship in 1999. She is a member of Sigma Xi and Gamma Sigma Delta. Her dissertation title is 'Manure Effects on Soil Phosphorus Sorption and Availability in Selected Minnesota Soils.' The results of her research are expected to provide a better understanding of the chemistry of the manure-soil-phosphorus complex. Her career goal is to research ways to minimize plant nutrient impacts on soil and water resources while maintaining or enhancing agricultural productivity and long-term sustainability.

R. Andrew Schofield was born in New Minas, Nova Scotia, Canada. He earned his B.S. degree from Acadia University in 1997. He received his M.S. degree from the University of Guelph where he is currently pursuing his Ph.D. degree. He was the recipient of the Colver Scholarship in Postharvest Physiology and the Soden Memorial Scholarship at the University of Guelph. His research focus is the 'Effect of Phosphorus Fertilization on Organoleptic and Nutritional Quality of Apples.' His study involves several aspects of apple quality and physiology with regard to phosphorus nutrition, including soil and foliar applications, absorption and transport parameters in tree and fruit, and the relationship between phosphorus fertilization and levels of compounds enhancing nutritional quality and storage. He plans a career in the area of plant physiology and biochemistry, perhaps as a university professor.

Eugenia M. Pena-Yewtukhiw is a native of Caracas, Venezuela. She received her B.Sc. degree from the Central University of Venezuela in 1984 and her M.Sc. from that same institution in 1992. She is presently studying for her Ph.D. degree at the University of Kentucky. Since beginning her doctoral program, she has been a recipient of both the Commonwealth and the Research Challenge Trust Fund Fellowships. Her proposed dissertation title is 'A study of Spatial and Temporal Variation in Soil Moisture Distribution in a Landscape Controlling the Response of a Corn-Soybean Rotation to Applied Fertilizers.' The objectives of her ongoing research activities are to determine those soil properties, as related to crop nutrient delivery, that are dependent on landscape; predict the distribution of those properties using advanced spatial analysis; and to use probability theory to suggest how crop response to soil management inputs will change with space and time. Ms. Pena-Yewtukhiw plans a career as a university researcher and instructor.

Mark L. Bernards was born in Murray, Utah. He received his B.S. degree from Brigham Young University in 1998 and plans to complete requirements for his M.S. degree at that university this year. Some of his many awards include the Brigham Young University Trustees Scholarship and the Julia Greenwell Scholarship. His thesis title is 'Screening Corn Hybrids to Determine Suitability for Use on High pH Soils by Measuring Phytosiderophore Release.' Many hybrids are unable to take up adequate iron at high soil pHs (above 8.0) because of iron insolubility. Using improved screening techniques and newly developed hybrids, Mr. Bernards believes that phytosiderophore release may be an effective and inexpensive screening technique for identifying iron-efficient hybrids. After his M.S. studies, Mr. Bernards plans to pursue a Ph.D. in agronomy, followed by a career as a university professor.

The Fellowships are named in honor of Dr. J. Fielding Reed, who served as President of the Institute from 1964 to 1975. Dr. Reed passed away in 1999.

The Fellowship winners are selected by a committee of PPI scientists. Dr. A.E. Ludwick, PPI's Western U.S. Director, served as chairman of the selection committee for the 2000 Fellowships. BC

WESTERN CANADA

Starter Potassium for Wheat and Barley on High Potassium Soils

By Rigas Karamanos and Norm Flore

Crop responses to nutrient applications are normally obtained as a result of a nutrient deficiency. Identification of nutrient deficiency is heavily dependent on either soil and/or plant tissue testing. Both tools can statistically provide an index of the nutrient status of a soil with great success. However, there are instances when a response to a nutrient is obtained on soils where the nutrient's soil test levels are far above what is considered as a critical or deficient level.

Westco Fertilizers of Calgary, Alberta, has had an extensive prairie-wide research program to assess responses of common cereal crops to seed-placed K in soils containing "available" K levels above what is considered optimum.

> Small grain response to potassium (K) and chloride (Cl) was inconsistent in this study. Researchers did not show a relationship between Cl application and disease suppression, soil type, cropping history, climate, and regional conditions. However, there was a strong relationship between frequency of response and the disease-susceptible barley varieties.

What Do We Mean by High Potassium Levels?

Research has been carried out in western Canada in order to calibrate soil tests against the yield of common crops. This work was successful, both in identifying K deficient soils on the Canadian prairies and deriving a critical level below which K deficiency occurs. A level of 125 parts per million (ppm) in the top six inches of soils, determined by ammonium acetate, is generally considered as the critical level. The majority of prairie soils test in excess of 300 ppm in the top 6 inches.

Why Is Potash Being Used in Soil with High Potassium Levels?

Application of small amounts (10 to 25 lb K_2O/A) of potassium chloride (KCl) in the seed-row is becoming an increasingly common practice in the western Canada prairies. This practice has been adopted in response to reported benefits from the Cl portion of the fertilizer. Yield responses to Cl have been attributed to disease suppression, especially in winter wheat. Sometimes, however, a yield increase due to Cl application is observed without any connection to disease suppression. Other potential benefits of placing small amounts of K with the seed include responses to K due to proximity of seedling roots to readily available K in cool springs, reduction in lodging, and promotion of early maturity.

What Is the Frequency of Crop Responses to Potash on High Potassium Soils in Western Canada?

During a 10-year period (1989-1998) more than 200 experiments with seed-placed K fertilizer on high testing soils were conducted in the three Prairie provinces (Alberta, Manitoba and Saskatchewan). **Table 1** contrasts the frequency and amount of response to a seed-placed application of 13 or 25 lb K_2O/A in the western Canadian prairies for spring cereals, 50 lb K_2O/A broadcast on winter wheat, and a

TABLE 1. Frequency of response and average grain yield increase from K application to spring and winter crops in western Canada and Montana.

Crop	Frequency of response, % Montana	Frequency of response, % Prairies	Average yield increase, bu/A Montana	Average yield increase, bu/A Prairies
Barley	40	40	3.7	4.6
Spring wheat	25	20	4.2	3.3
Winter wheat	50	N/A[1]	3.9	1.8[2]

[1]Not available.
[2]PPI/PPIC/FAR sponsored research from Dr. D.B. Fowler, University of Saskatchewan.

broadcast application rate of 25 lb K_2O/A on all cereal crops in Montana.

Results indicate that barley had the highest probability of giving a yield response to added K in western Canada, with 15 percent of trials showing a 5 to 10 bu/A yield response, and 40 percent of trials having at least a 2 to 5 bu/A response. The frequency of response for spring wheat was lower, with 20 percent of trials having a 2 to 5 bu/A yield increase. The results from Montana indicate that the frequency of response with winter wheat is even higher than spring cereals. This reflects in part the role of Cl in reducing the incidence of physiological leaf spot, a non-disease leaf spotting symptom associated with certain winter wheat varieties. The trials measured kernel plumpness of barley and days-to-maturity and protein of both barley and wheat. However, none of these variables showed any response to the K application.

Why the Benefits from Seed-Row K Application on Soils with High Potassium Levels?

Our work and the work of other scientists have not fully explained this behavior. We tried to relate apparent yield increases to disease suppression by the Cl portion of the fertilizer, soil type, previous crop, and climatic or regional conditions, but could not come up with either a consistent trend or sometimes any trend at all. However, we could establish a very strong relationship between frequency of response to KCl and barley variety. This provided us with an indirect link between response and disease resistance. Varieties with lower disease resistance, such as Harrington, showed a 2 to 5 bu/A yield increase 50 percent of the time and a 5 to 10 bu/A increase 20 percent of the time. However, varieties with superior disease resistance, such as Leduc, Stander or Manley, did not respond as frequently.

Conclusion

Certain barley varieties grown on western Canadian prairie soils containing high available K levels do respond to seed-row applied KCl every two to three years out of five. We were unable to associate this response with soil Cl levels, root rot infection, climatic conditions, soil type, or previous crop. This type of response was less likely with hard red spring wheat (less than two out of five years). We are also unable to establish a benefit of seed-row KCl placement on decreasing days to maturity and grain protein or increasing plumpness of malting type barley. However, from both agronomic and economic perspectives and because we still cannot fully explain this behavior, K applications on soils containing high levels of available K are strongly recommended only with barley varieties that appear to be susceptible to disease. BC

Dr. Karamanos is Manager, Research & Market Development, and Mr. Flore is Manager, ACES Program, Westco Fertilizers Ltd., Calgary, Alberta.

Fertilizing for Wheat Yield and Quality

By T.S. Murrell

Data from Colorado on dryland winter wheat showed significant yield increases to nitrogen (N) in 10 of 19 site-years. Significant protein increases occurred in 17 of 19 site-years, or about 90 percent of the time. Under irrigated conditions, yield increases may be achieved more frequently.

As recommendations are created for N and phosphorus (P) management for wheat, it is important that the impacts on protein be considered.

An example of the combined responses of hard red spring wheat yield and protein content to N fertilization is shown in **Figure 1**. Irrigated yield response to N was curved, and protein response was linear. Gross revenue (**Figure 2**) was a function of both yield and price increases from higher protein content. Costs included in this calculation were: soil sampling ($0.45/A), fertilizer N ($0.15/lb N), broadcast application ($3.27/A), harvesting ($0.10/bu), hauling ($0.16/bu), and grain handling ($0.07/bu). Net crop price was a step function, since price was assumed to increase ($0.05/bu) for higher protein or decrease ($0.07/bu) for lower protein every 0.25 percent relative to the $2.88/bu base price for 14 percent protein wheat. A min-

Protein is a valuable quality component of wheat. Higher protein content in hard red wheats can translate to better flours and, most importantly for the farmer, higher commodity prices. Proper fertilization is a critical management strategy for higher protein wheat.

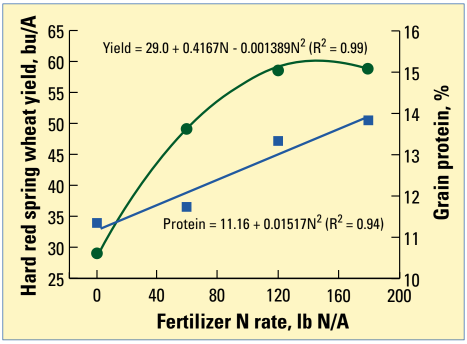


Figure 1. Irrigated spring wheat yield and protein response to N fertilization in 1995 at Bozeman, MT, no late-season N applied. (Westcott, M. 1998. How to get higher spring wheat protein more efficiently. MontGuide MT9806ag. Montana State University Cooperative Extension Service, Bozeman. Available online at http:/www.montana.edu/wwwpb/pubs/mt9806.html).

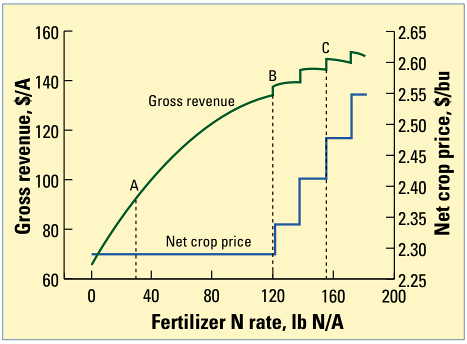


Figure 2. Gross revenue and crop prices at various N rates for the data in Figure 1. Line C denotes the optimum rate of N. Line A denotes the N rate where added revenue is great enough to pay for all fertilization costs at the optimum rate. Line B is the N rate producing revenue great enough to cover total costs of production, excluding irrigation expenses.

imum price of $2.62/bu was used. This was the lowest price available for low protein spring wheat at the time this article was written and included a loan-deficiency payment (LDP).

TABLE 1. Comparison of net gains to net losses in N response regions defined in **Figure 3**.

Region	Cumulative net losses from incremental increases in N rate	Net gain from price increase	Net gain + cumulative net losses	N rate at end of region where price increase occurred, lb N/A
	$/A			
1	-2.92	51.56	48.64	127
2	-0.33	2.01	1.77	138
3	-1.97	2.01	0.04	155
4	-3.54	1.85	-1.69	171
5	-3.34	0.00	-3.34	—

Jumps in gross revenue complicated calculations of optimum rate. Optimum rate is usually defined as the rate at which an increment of fertilizer produces a response equal in value to its cost. Such a definition assumes N response behaves in a classical manner, as in **Figure 1**. Nitrogen rates higher than optimum would result in yield increases too small to cover additional N costs. However, in this case, increasing N beyond such a point ($ return/$ invested = 1) resulted in increased crop prices due to higher protein content (**Figure 3**). The benefit of an increased price had to be weighed against the losses in marginal returns incurred before the price increase was encountered. Responses to N were divided into five regions. Region 1 was characterized by steadily decreasing marginal returns and a jump in crop price. The ratio of incremental income to incremental cost was 1 or above for this region. The first increment of fertilizer resulted in marginal returns less than 1 since it incurred all sampling and application costs in addition to an incremental N cost. Regions 2-4 were all characterized by marginal returns less than 1 followed by a price increase. Region 5 was marked only by declining marginal returns.

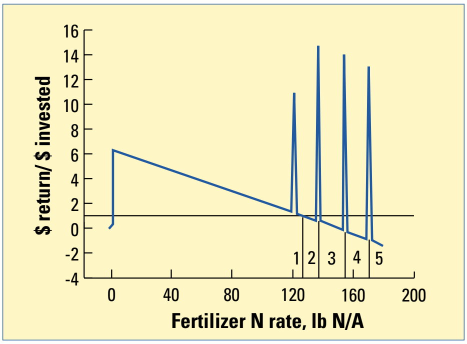


Figure 3. Marginal returns ($ return/$ invested) at incremental N rates. A reference line for a ratio of 1 is provided. Sharp features represent increases in overall crop price from protein improvement.

For each region, cumulative net losses were compared to net gain from the price increase (**Table 1**). If net losses were less than the net gain, then the additional N was considered profitable. Such comparisons in **Table 1** result in an optimum rate of 155 lb N/A, which generated gross revenue of $150/A. Beyond this rate, losses were too great to be recovered by an increased price. If an optimum rate had been calculated assuming a fixed protein content of 14 percent, the recommendation would have been 129 lb N/A which would have generated gross revenue of $140/A. Not accounting for price increases from protein would have resulted in an N recommendation of 26 lb N/A less and would have lowered gross revenue by $10/A.

Aiming for higher protein content in wheat incurs certain risks. The prices associated with various protein percentages vary by year and are based on factors related to weather and crop conditions that affect supply and demand of higher protein wheats.

Research is being conducted in the U.S. and Canada to determine factors important for estimating whether premiums or deductions are likely to occur within a given year. Also, late applications of N, such as those investigated in Montana, may allow producers to target higher protein when better estimates of market conditions are available.

(continued on page 20)

Map Making for Variable Rate Fertilization

By Harold F. Reetz, Jr.

Variable rate technology (VRT) fertilizer application requires a guidance map to relate the position of the equipment to prescribed application rates for specific areas of the field. Even the most extensive soil sampling schemes measure only a small fraction of the soil and then use that information to estimate the plant-available nutrient levels across the field. For example, to estimate the soil test levels for point *x* in **Figure 1**, information gathered from points A, B, C, and D can be used, each adding a little more information about point *x*. The ability to estimate values for point *x* (and other unknown points) improves as the number of sample points increases. For this reason, more intensive sampling is desirable when developing a site-specific nutrient management plan. But there is a limit to the cost/benefit relationship of intensive sampling at some point. Sampling at distances as short as 110 feet, or a one-acre grid, becomes too expensive for most farmers.

Larger grid sizes for soil sampling often miss some areas needing nutrients. But sampling at smaller grid sizes, such as one acre, becomes too expensive for most farmers. A study at the University of Illinois is looking at effectiveness of various alternatives.

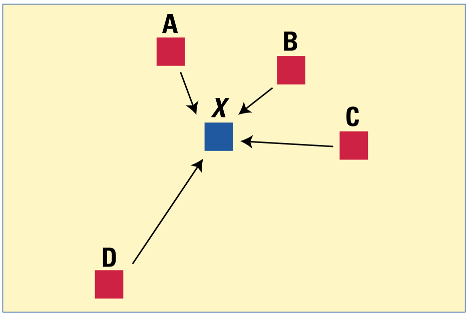
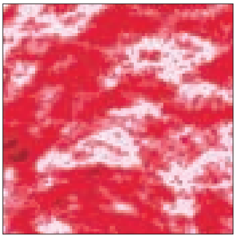
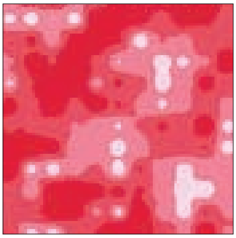
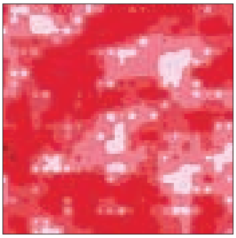
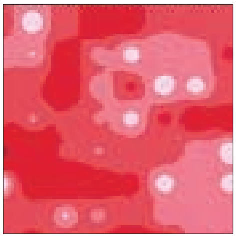


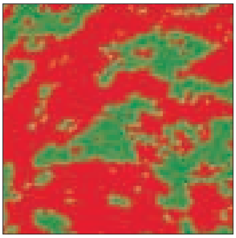
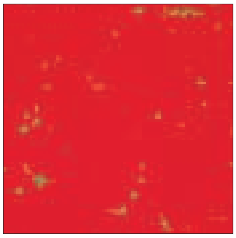
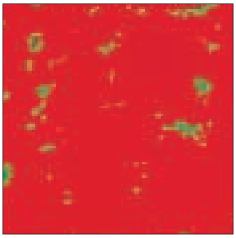
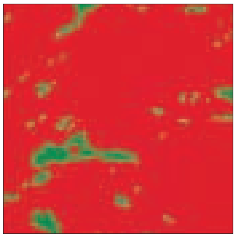
Figure 1. The soil test P level value of point x can be estimated from information known about points A, B, C, and D. A larger number of nearby samples provides more information on which the estimate of x can be based.

To demonstrate the importance of intensive sampling, Dr. Don Bullock, University of Illinois, produced a series of simulated sampling scenarios based on the characteristics of an actual central Illinois field, with the phosphorus (P) fertility variability shown in **Figure 2**. This P fertility map was generated by collecting more than 1,500 actual samples at various distances apart, then using the spatial structure of the data to develop a 1,000 x 1,000 point grid of the 640-acre field, or the equivalent of *1 million soil samples*. Darker color indicates a greater P soil test in that part of the field. The database generated was then "sampled" at 110-foot, 220-foot, and 330-foot grids to compare the relative effectiveness of these sampling densities in characterizing the real soil nutrient status of the field.

This field has a mean P fertility of about 40 lb P/A and has a range of spatial correlation of 600 feet. In other words, information from any given point can be expected to help estimate information about another point within 600 feet. **Figure 3** shows a 110-foot grid sampling simulation of the field. **Figures 4** and **5** show 220-foot and 330-foot grid sampling, respectively. Current University of Illinois recommendations suggest that fields be sampled on a 2.5-acre (330-foot grid) basis.

(From left to right):
Figure 2. Actual P fertility map based on very intensive sampling. Darker areas indicate higher P.
Figure 3. P fertility map based on 110-foot grid sampling simulation of data from **Figure 2**.
Figure 4. P fertility map based upon 220-foot grid sampling simulation of data from **Figure 2**.
Figure 5. P fertility map based upon 330-foot grid sampling simulation of data from **Figure 2**.

(From left to right):
Figure 6. Areas of field actually needing buildup P are shown in green.
Figure 7. Areas needing P that are missed with a 110-foot (1-acre) sampling grid are shown in green.
Figure 8. Areas needing P that are missed with a 220-foot sampling grid are shown in green.
Figure 9. Areas needing P that are missed with a 330-foot (2.5 acre) sampling grid are shown in green.

Comparing **Figures 3**, **4** and **5** to **Figure 2** (the actual field), it is clear that P fertility maps become progressively poorer as the grid size increases. More areas needing fertilizer are missed with the larger grid sizes.

Which map will best estimate the true nutrient status of the field? The worst mistake would be to declare that an area does not require fertilizer (e.g. P > 40 lb P/A), when in fact, fertilizer is needed to optimize crop growth (e.g. P < 30 lb P/A), based on the University of Illinois Agronomy Handbook. Areas of the actual field which have P soil test values of less than 30 lb P/A are shown as green and represent 38 percent of the field (**Figure 6**). Simply using a mean P soil test value and a uniform, field-average application rate, very little P fertilizer would be applied, since the mean of the field is approximately 40 lb P/A. So 38 percent of the field represents the missed opportunity for increased yield potential if the farmer used a field-average nutrient management program. It also represents missed market opportunity for the dealer supplying fertilizer to that farmer. Comparison of **Figure 6** to **Figures 7**, **8**, and **9** indicates progressively more mistakes (i.e. not fertilizing areas that need fertilizing) as grid size increases. However, even the 330-foot grid (**Figure 9**), misses only 9 percent of the field needing P buildup, and thus is much better than the simple field-average uniform rate.

The 220-foot and 110-foot sampling grids miss only 4.5 and about 2.5 percent of the areas requiring fertilization, and are thus substantially better than the 330-foot grid. The generally good performance of the 330-foot (2.5-acre) grid in this example is mainly due to the 600-foot spatial correlation. As the range of spatial correlation decreases, the performance of the 330-foot grid will decline.

To determine whether a 330-foot grid gives an accurate estimate of nutrient variability, Dr. Bullock recommends sampling on a 330-foot grid, then collecting 25 percent more samples at random to help identify additional variability not captured by that sampling grid. That would mean collecting 32 grid samples on an 80-acre field, with eight additional random samples, for a total for 40 samples. Plotting a semi-variogram, you can determine whether the sampling points are close enough together to assume spatial correlation between points. If the plot shows points are not correlated, accurate interpolation between points is not possible and they should be treated as independent values. BC

Dr. Reetz is PPI Midwest Director, located at Monticello, Illinois. E-mail: hreetz@ppi-far.org.

This work is a part of the technology development and evaluation under the Site-Specific Crop and Soil Management Systems project sponsored by the Foundation for Agronomic Research and PPI with major support from the United Soybean Board, the Illinois Council for Food and Agricultural Research (C-FAR), and co-sponsorship from a wide range of other partners.

Fertilizing for Wheat... *(continued from page 17)*

Environmental risks are also present. Fertilizing for higher yields when moisture becomes limiting can lead to higher residual N left in the soil profile. Soil testing to determine the quantity of N present at the start of the next growing season is critical to using N effectively.

TABLE 2. Response of the Hi-Line hard red spring wheat variety to N and P fertilization (five-year average), G.R. Carlson, unpublished.

Variety	Treatment	Yield, bu/A	Protein, %
Hi-line	66-33-0	42.58	14.31
Hi-line	unfertilized	24.41	10.97
Increase from fertilizer		+18.71	+3.34

TABLE 3. Economic impact of N and P fertilization on the Hi-Line hard red spring wheat variety, G.R. Carlson, unpublished (prices used are same as for **Figure 2**).

Treatment	Selling price $/bu	Total costs	Return to fertilization costs	Return to total costs
		$/A		
66-33-0	2.93	128.16	28.93	-17.45
Unfertilized	2.62	109.85	0.00	-53.95
Difference	+0.31	+18.31		+36.50

Balanced fertility is important to environmental protection as well as profits. Paying attention to all nutrient needs is central to profitable wheat production. As an example, data in **Tables 2** and **3** show the impact of a fertility program that includes both N and P. These data show that N and P work together to increase yield, protein content, selling price, and returns. Although returns to fertilization were good, returns to total costs were negative for both the fertilized and unfertilized cases. Under current low crop prices and depressed economic times, fertilization may not guarantee positive returns, but proper fertilization can minimize losses. A recent survey by PPI found that 34 to 90 percent of the soil samples tested in major wheat producing states were medium or below in P. Rectifying deficiencies of nutrients, such as P, is necessary for increasing production and gross revenue.

One of the major concerns of dryland wheat production has been financing a fertilization program. Margins in such systems are narrow. Producers often struggle to get loans for needed fertilizer. Balanced fertility that targets higher protein may help producers find much needed revenue that will widen profit margins and further develop an upward cycle of land improvement and profitability. BC

Dr. Murrell is PPI Northcentral Director, Woodbury, Minnesota. E-mail: smurrell@ppi-far.org.

Virginia: Phosphorus and Potassium Fertilizer Recommendation Variability for Two Mid-Atlantic Coastal Plain Fields

The objective of the study was to compare soil test results for phosphorus (P) and potassium (K) recommendations. Two fields were chosen and two grid sample sizes (0.82 acres and 2.05 acres) utilized. Also, sampling was done by soil type composites and by standard whole-field composite sampling. Two statistical models were developed to compare P and K soil test data and resulting fertilizer recommendations.

- Precision farming model
- Whole-field composite sampling model

The smaller grid (0.82 acres) resulted in more precise estimates of extractable K in only one field...with 67 percent of locations receiving appropriate K rates...but with no improvement for extractable P in either field when compared to the 2.05 acre sampling grid. Both improved precision for P and K, with a smaller average misapplication rate, compared to the whole-field composite. Compositing by soil type was superior to the whole-field approach for estimating P and K levels and resulted in lower average misapplication...and a higher percentage receiving appropriate nutrient rates. It also approached the grid-sampling system precision of fertilizer recommendations for large in-field variation.

Researchers concluded that only when strong trends in extractable P and K exist would grid sampling be recommended over composite-by-soil-type sampling.

Source: Anderson-Cook, C.M., M.M. Alley, R. Noble, and R. Khosla. 1999. Soil Sci. Soc. Am. J. 63: 1740-1747. (This study was part of the Mid-Atlantic Cropping Systems Regional project partially supported by FAR/PPI.)

Iowa: No-Tillage Corn Hybrid Response to Starter Fertilizer

Researchers collected nine-site years of data from farms near four Iowa State University research farms, 1993 to 1995. Soil test phosphorus (P) levels were high at three of the four sites. Potassium (K) levels were medium for four of the nine site-years, so K was broadcast before planting. Plot size, starter fertilizer rates, and hybrids varied among sites. Crops were planted with and without complete starter fertilizer which was applied in a band 2 inches to the side and 2 inches below the seed. Corn was rotated with soybeans, and no-till cultivation was used. Planting dates varied depending on weather, but planting was completed before May 20 each year.

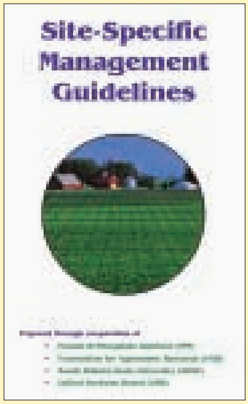
There were no starter-by-hybrid interactions. Starter fertilizer significantly increased early-season growth in four of eight site-years and grain yield in seven of nine site-years. Averaged across hybrids, starter treatments increased yields from 4 bu/A at one site in 1993 to 18 bu/A at another in 1995.

Authors concluded that test results suggest a complete starter fertilizer will likely be beneficial in no-tillage corn in the northern Corn Belt, even on soils where P and K are considered to be adequate.

Source: Buah, S.S.J., T.A. Polito, and R. Killorn. 1999. J. Prod. Agric. 12(4):676-680.

Site-Specific Management Guidelines Series

The *Site-Specific Management Guidelines* (SSMG) series was introduced at the 1999 Information Agriculture Conference (InfoAg99). The SSMG series is the result of a cooperative effort between South Dakota State University and PPI/FAR.



The objective of the project is to provide a mechanism to assemble expert knowledge in a timely fashion on site-specific management, in a form useful to farmers and their advisers.

Each Guideline addresses a subject or issue related to site-specific soil and crop management. The Guidelines are available individually or as a set in a three-ring binder. The format provides flexibility needed to stay current with the dynamic knowledge base surrounding site-specific technologies.

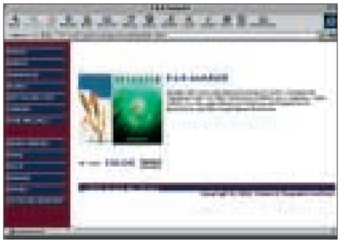
The SSMG series at present includes 29 topics, each two to four pages. Following is a list of the topics.

1. Site-Specific Use of the Environmental Phosphorus Index Concept
2. Management Zone Concepts
3. Profitability of Site-Specific Farming
4. How to Determine an Accurate Soil Testing Laboratory
5. Developing Management Zones to Target Nitrogen Applications
6. Global Positioning System Receivers
7. Variable Rate Equipment – Technology for Weed Control
8. Standardization and Precision Agriculture – 'The Promised Land'
9. Yield Monitor Accuracy
10. The Pioneer Split-Planter Comparison Method
11. The Earth Model – Calculating Field Size and Distances between Points Using GPS Coordinates
12. Assessing Crop Nitrogen Needs with Chlorophyll Meters
13. Identifying Good Candidates for Precision Phosphorus Management
14. Selecting a DGPS for Making Topography Maps
15. Scouting for Weeds
16. Remote Sensing: Photographic vs. Non-Photographic Systems
17. Setting Up On-Farm Experiments
18. Simple On-Farm Comparisons
19. Area-Wide Management Zones for Insects
20. Estimating the Timing of Weed Emergence
21. Field Testing Management Zones for VRT
22. Potential Applications of Remote Sensing
23. Getting Specific with Site-Specific Nutrient Management
24. Grain Protein Sensing to Identify Nitrogen Management in Spring Wheat
25. Weed Biology and Precision Farming
26. Interpreting Remote Sensing Data
27. Spatial Variability in Corn and Soybean Insect Pests: Precision Farming and Insect Pest Management for the Future
28. Strategic Approach to Site-Specific Systems
29. Geographic Information Systems in Site-Specific Systems

To order the complete set of 29 topics in a binder, send US$15.00 plus shipping/handling of US$6.50 (U.S. delivery) or US$9.00 (Canada delivery) to Potash & Phosphate Institute, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837. For ordering information on multiple binders or quantity purchases of separate topics, call the PPI Circulation Department at (770) 825-8082, (770) 825-8084, or fax to (770) 448-0439.

To preview the Guidelines online or to learn about future updates and new topics that might be added to the series, check the website at: **www.ppi-far.org/ssmg**. BC

Agronomic Information Materials Now Available Online from PPI/PPIC/FAR



A new service introduced by PPI/PPIC/FAR will facilitate online ordering of publications and other information materials from the organization. The "Store" will enable shoppers to select individual publications such as the *Soil Fertility Manual* or packets of items such as *Plant Problem Insights* cards, then provide delivery instructions and payment by credit card.

"Many of the audiences we serve through various programs have encouraged this new arrangement," explained Dr. B.C. Darst, PPI Executive Vice President. "While we continue to offer traditional methods of handling orders for publications, videos, CDs, and other items, many individuals prefer the convenience of online shopping. The PPI Catalog of materials for the year 2000 was distributed to audiences in industry, schools, agencies, and other clientele where agronomic information is needed."

While the "Store" does not currently offer all the information items available from the Institute, many of the frequently purchased items are featured. Future additions and developments are expected.

The online site uses the "shopping cart" concept to accommodate selection of multiple items. Visitors can browse through various categories of information by simply "clicking" on topics of interest.

For a limited time, no shipping/handling charges will be added to orders received via the "Store" site on the Internet. The special offers on packaged items and waiver of shipping charges are not available on orders received by fax, phone, or mail.

For more explanation, contact the PPI Circulation Department at (770) 825-8082 or 8084, or e-mail to: circulation@ppi-far.org.

The "Store" online can be reached through a link on the PPI/PPIC/FAR home page found at either **www.ppi-far.org** or **www.ppi-ppic.org**.

Earl H. Bailey, 1902-2000

Mr. Earl Hicks Bailey, who served for 31 years as an agronomist with the American Potash Institute (forerunner of PPI), passed away February 14, 2000 at the age of 98. A native of Mississippi, Mr. Bailey lived in Starkville since 1923. He attended Mississippi A&M, where he continued as a botany professor for nine years.

Mr. Bailey was a Life Member of the Mississippi State University alumni association and maintained membership in the American Society of Agronomy and other organizations. An avid gardener, Mr. Bailey raised orchids and other unusual plants after his retirement. He also published a book of poetry, reflections of his life and family.

Survivors include a son, James Earl Bailey, and a daughter, Patsy Bailey Randle (Mrs. William), two sisters, a brother, five grandchildren, and eight great-grandchildren.

P and K and ERG – A Plan for Healthier Eating

Here at the Institute we recently introduced a new research initiative, **Managing Crop Production for End-Use Quality**. It has some noble goals, like boosting the production of therapeutic and medicinal compounds in plants, to make our diets more healthy. Among other things, it proposes to examine the effects of P and K nutrition on the plant's ability to manufacture certain 'nutraceuticals.' It's designed to attract farmer interest in capturing value-added opportunities and to help consumers make more 'informed' decisions about healthy eating. It could even influence the medical/dietary science community to develop a better understanding of agriculture. The most important objective, though, is to demonstrate the positive relationship between P and K and human health.

Not long ago my Sunday paper devoted a whole section to America's bad eating habits and their effect on our health. Too many of us are overweight. We load up on junk food and ignore the basics of proper diet. My mom must be turning over in her grave. Her kids didn't eat junk food (she thought) and didn't have to sit down to a bowl of cold cereal because she was too lazy (Mom's words, not mine) to cook a 'healthy' breakfast of ham and bacon and fried eggs and buttered biscuits and whole milk. It's now claimed that a good number of us don't even have time to eat that cold cereal anymore. If it's not pre-packaged or can't be nuked in a microwave and taken with us, we don't have time.

The research we propose to do has the potential to improve our health. If so, the world will surely learn to appreciate P and K...and all of agriculture...more. Still, I wish we could introduce an ERG (Eat Right Gene) somewhere in the mix. Maybe we would eat better and even take the time to slow down enough to let the food digest properly. Like at the dinner table with the family. Probably an idea ahead of its time.

BETTER CROPS WITH PLANT FOOD

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