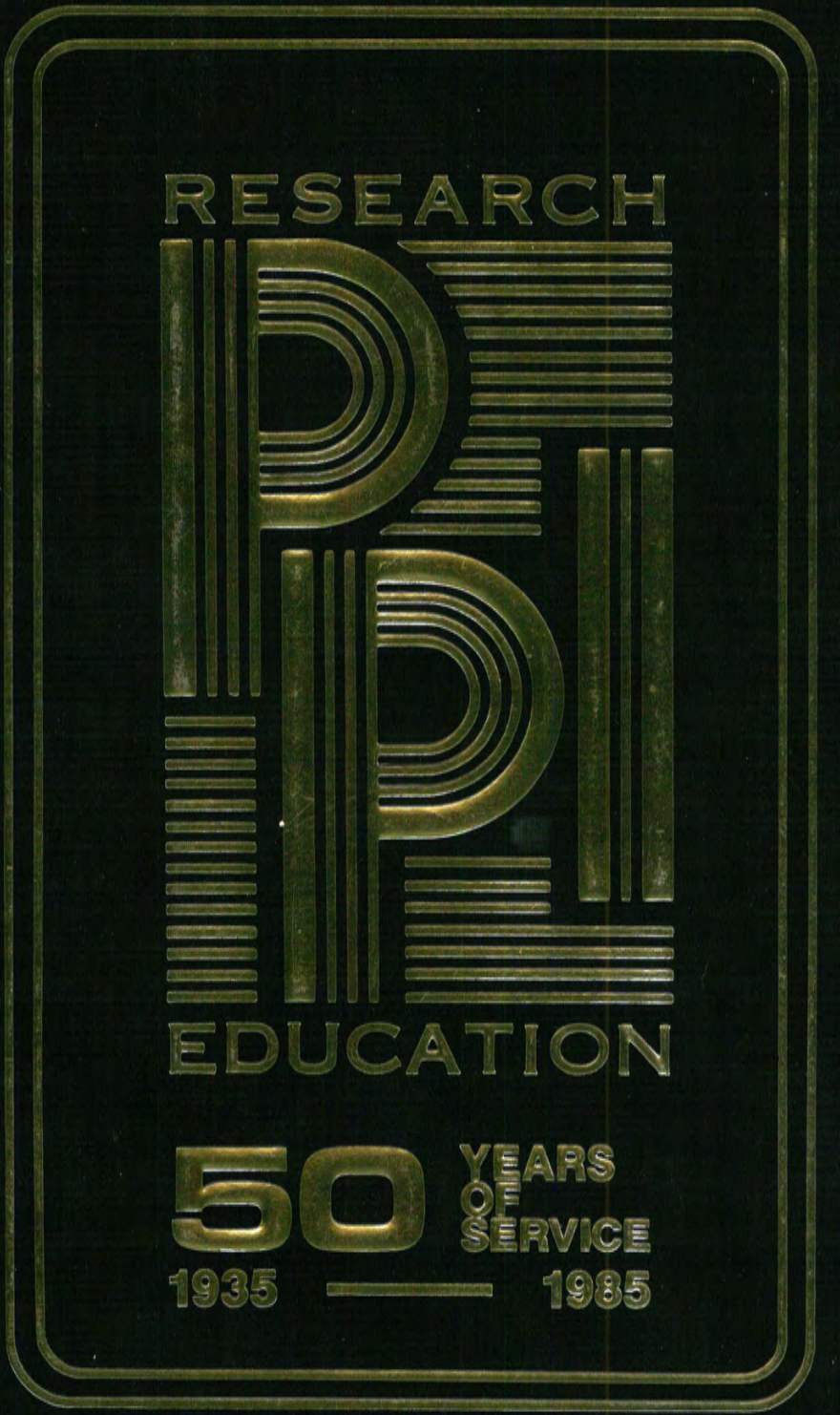
BETTER CROPS
with plant food
SUMMER 1985



THE WHITE HOUSE
WASHINGTON
April 3, 1985

I send warm wishes and congratulations to you, the members and staff of the Potash & Phosphate Institute, as you celebrate the golden anniversary of the Institute.

This is a good time to recognize the vital role that the Institute performs in building cooperation among farmers, businesses and the scientists and personnel of our great network of land-grant colleges and state experiment stations.

The Institute's 50 years of dedicated support of agricultural research have helped this Nation achieve a productivity second to none. It has trained leaders in farming and every associated field.

I commend you for your cooperation with agronomists around the world, and for carrying the generosity and friendliness of America abroad.

May you enjoy continued success in cooperation with those who work to feed expanding populations while conserving the earth's precious agricultural resources.

Ronald Reagan

PPI's 50 Years to MEY

By R.E. Wagner

THIS IS A TIME OF CELEBRATION . . . time to recognize PPI's 50 years of service to world agriculture. We especially salute our member companies who have faithfully supported this Institute, some for a half-century, some a bit less, and some only in recent years.

More than anything else, this steadfast support generated by the pride and the confidence of member companies in its Institute has made it possible to staff with outstanding people and to retain them. The opportunity to cooperate with university and government personnel and with industry representatives is a great strength.

The insistence of member companies on scientific credibility and on a quality staff that gives credence to credibility and to meaningful and highly accepted market development programs has not wavered. These philosophies and policies mapped the route to the reputation PPI enjoys and cherishes today. Deserving and protecting that cherished position are tomorrow's challenges.

Throughout its 50 years PPI has geared its programs to the needs of supporting industries, consistent with what was best for the farmer and for feeding people. The organization has been responsive to those needs as they have changed.

PPI's 50 years bracket the kinds of changes in North American agriculture that earned its position as the envy of the world. And, now, changes that present special challenges. Let's look at just a few.

- In 1935, one in 5 of the U.S. population was on the farm. Today, only one in 40, less than 3%.
- In 1940, one U.S. farmer fed 11 people; today, 78.
- In 1940, one U.S. farmer fed 0.4 of a person abroad; today, 26.
- From 1910 to 1940 corn yields increased 2%; since 1940, 221%.
- Hybrid corn unleashed an impact on agriculture beginning in the late 1930's that is unequaled any time in history.
- '70's were known as the decade that built exports and a strong market for U.S. grains . . . the major step in moving U.S. agriculture from a domestic cocoon to a global supplier.
- '80's have seen decline in exports . . . new highs in farm debt . . . new highs in government payments . . . new highs in concerns for farmer survival.

Maximum Economic Yield

Real progress in meeting current and future challenges will be highly related to MEY (maximum economic yield) . . . a concept with low unit costs for farmers and low food costs to consumers, its great strength. Wherever it might be, maximizing the economics of production and the conservation of soils should be the goal.

PPI's story from potash to MEY is an interesting one and has distinct chapters. The Institute's first 42 years focused on potash. At the time the Institute was created

Dr. Wagner is President of the Potash & Phosphate Institute (PPI) and the Foundation for Agronomic Research (FAR), Atlanta, Georgia U.S.A.

in 1935, phosphate consumption in the U.S. exceeded that of potash by nearly a 2:1 ratio. . . 597,000 tons to 307,000 tons. PPI's and others' efforts narrowed that gap through the years and finally closed it in 1974. Consumption of the two remained essentially the same for 3 years; then in 1977 potash pulled ahead for the first time in history. In other countries, like Korea and Indonesia, PPI's entry into market development programs also sparked a substantial increase in potash consumption.

These successes caught the attention of the phosphate world, and in 1977 phosphate producers joined forces with potash companies to support research and education programs on P; and because it would become a stronger total agronomic program, it would also help K.

The Systems Approach

This step marked the beginning of the systems or multidisciplinary approach for PPI, which led to the implementation of MEY as we know it today.

To foster the concept, primarily through maximum yield research, and to provide a vehicle through which a broad base of producers of farm inputs could lend support, the Foundation for Agronomic Research (FAR) was created in 1980. Since that time funds have been provided not just by the potash and phosphate industries but also by seed, nitrogen, sulfur, micronutrient, and chemical companies, and by dealers.

More and more, industry recognizes that its own products must relate to others in a high yield system and perform well if they are to sell. The most effective way to get a response from any given input is to ensure that all other inputs in the system are adequate.

No longer can we be concerned with a single factor or a single product in isolation. As yields increase, interactions among components of the total system become more significant. The goal is to seek out the **positive interactions** and to put them into play.

Farm Policy

As the U.S. contemplates its farm policy direction for the years ahead, cost containment and a market oriented farm economy are key. Cost containment not only in terms of government costs but also for farmers is central to strengthening our export market. A lower-cost product but still at a level which gives efficient farmers a respectable profit is a strong competitor in the international market at minimal cost to the government.

With agriculture at a rocky crossroads and with divergent opinions on which road to take for a healthy future, an industry supported market development organization of the PPI kind has a more crucial role than ever in the history of farming. PPI can best help by continuing its sharp focus on MEY agriculture.

International Emphasis

In its early history, the Institute's attention was given almost exclusively to North American markets. That, too, has changed and we are moving even faster into the international arena. Food needs are greatest in the developing world. It is here that the North American industry can be of greatest help. . . and here the major market potential exists. Already, PPI and FAR support maximum yield research projects in China, Peru, Ecuador, Brazil, Philippines and Indonesia. The potential for doubling P and K consumption in the next 5 years in China and sharply increasing use of other inputs makes this country an especially attractive target.

For The Future

It is fitting that this story be told in this Golden Anniversary issue. . . the story of PPI's road to MEY in 50 years. . . how it has all come together to provide the base for the next 50. Others will fill in more of the details.■

BETTER CROPS with plant food

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Contents

The Board of Directors' View of the Potash & Phosphate Institute

By Douglas J. Bourne

THE FARMER, on whatever land he toils, is both our supplier and our customer. All of us depend on him for the food and fiber vital to the exploding world population. In turn, he depends on us and our industry for his raw materials.

The farmer is a business venture subject not only to the vagaries of the weather, but also to capricious regulation, as governments attempt to frustrate the laws of the marketplace. How, then, can we help our embattled customer and ourselves in the bargain? We can help by giving him the keys to maximum economic crop production.

Maximum economic production is determined from maximum yield research. This research is the driving theme of all efforts of the Potash & Phosphate Institute (PPI) through the Foundation for Agronomic Research (FAR).

There is no better organization than PPI to undertake this critical endeavor. PPI's record for replicated, quality research has been building over the entire fifty (50) years of its history. Its professional staff represents the highest quality and integrity of agronomic science. This staff has been built slowly and carefully over the years. The loyalty, dedication and performance of its members have been outstanding.

Significant progress has been made in seeking and identifying the facts about maximum yield. This has been done with many crops under varying conditions of weather and soil. This is a never ending task of constantly raising the target and constantly accommodating new developments in nutrients, pesticides, equipment, etc.

However, knowing the facts is but half the task. The facts shed no light until they are communicated to our customer, the farmer. Communicated in a way that he, and sometimes his banker, can believe without question and use with confidence to determine his maximum economic operation.

The PPI willingly and enthusiastically undertakes this mission. It has the wholehearted support of its member companies and the contributors to FAR. Throughout PPI's history, this splendid scientific organization has been evolving toward this goal. It will never be satisfied with less. ■

Mr. Bourne

Mr. Bourne is Chairman and Chief Executive Officer (CEO) of Duval Corporation, and is currently serving as Chairman of the Boards of Directors of the Potash & Phosphate Institute (PPI) and the Foundation for Agronomic Research (FAR).

Contents. . .continued

Fifty Years of Progress

By J. Fielding Reed

FIFTY YEARS AGO, the American Potash Institute was launched on an important and unique experiment in cooperation.

The time was July 1935. The place was Washington, D.C. in a room about three blocks from the White House. The man speaking was Dr. J. W. Turrentine, first President of the new Institute and a chemist of considerable reputation. He was a world authority on the production and use of potash.

Upon this occasion he was not speaking to a hall full of official scientists. He was making a point to a group of 8 men—the Institute's first Board of Directors. They were top-level officials from the nation's major potash producers of that day, realistic businessmen with the goal of selling potash for a profit.

Dr. Turrentine's message was short and to the point: "Gentlemen, potash use depends on the recognition of its function as a plant food, which is agronomic, and the ability of the farmer to buy his requirement, which is economic. In fact, the agricultural usage of potash must be increased **only** on a basis that is sound and profitable to the farmer".

"...potash use depends on the recognition of its function as a plant food, which is agronomic, and the ability of the farmer to buy his requirement, which is economic. In fact, the agricultural usage of potash must be increased only on a basis that is sound and profitable to the farmer".

America's potash industry accepted his philosophy and, through their Institute, for 50 years has held to that concept: applying scientific integrity to the wheels of commercial enterprise.

Cooperation has been the key. Cooperation with thousands of research scientists, teachers, advisors, and other members of official agriculture—with salesmen, dealers and farmers at the grass roots level—always with sincerity and dedication to the truth.

Organization

The concept of a scientific institute in the potash industry actually did not

Dr. Reed is a former President of the Institute. Since retiring from the position in 1975, he has continued to serve as a Consultant.

originate with the American Potash Institute. For many years prior to 1935, most of the potash used by American farmers was imported from Europe. It was marketed through an organization known as N. V. Potash Export My, Inc. of Amsterdam, Holland. The European potash producers were strong believers in research and educational programs. During the 1920's N.V. had created an **Agricultural and Scientific Bureau** with headquarters in New York City and regional offices throughout the U.S. This Bureau was staffed with competent agronomists, and also boasted a fine publications staff.

This group of scientists became the nucleus of API when the Institute was established. The scientific program was moved from New York to Washington, D.C. The Institute shared a building with the American Chemical Society until July 1951. At that time, a 5-level home was purchased on 16th Street and converted into a very attractive office building. This continued to be headquarters until 1968 when that building was sold and the headquarters moved to Atlanta, Georgia.

The European members left the Institute at the beginning of World War II. When production of potash began in Canada in the 1960's, most of these producers joined the Institute. Since American meant the United States to much of the world, the Institute became the Potash Institute of North America. Later this was shortened to the Potash Institute. **(continued on next page)**

In 1977, the integration of phosphorus into the Institute involved a further name change to the **Potash & Phosphate Institute (PPI).** There was no change in emphasis, and the programs were actually strengthened. In reality, the Potash Institute had long been promoters of phosphorus. It was essential to the development of markets for potash. The two elements go hand in hand in a sound fertility program. Thus, the objectives, principles, and methods of approach of the Potash Institute were retained and simply enlarged in scope.

The creation of the **Foundation for Agronomic Research (FAR)** resulted from the interest of several members of PPI in an expanded research effort — over and above that possible with PPI's budget. The entire agricultural industry had a tremendous stake and obligation in promoting research to increase efficiency of crop production and to discover the place of all inputs (such as fertilizer, seed, chemicals, machinery, etc.) in profitable crop production.

PPI had the experience, expertise, know-how, and staff to accomplish such a task. So, to take advantage of the resources of PPI, in 1980 a new organization was created. FAR offers all segments of the agricultural industries an opportunity to fulfill their responsibilities to support research designed to increase farm profits and to improve the welfare of their customers.

The Foundation is in its infancy, but the principle is sound. It remains for all of agriculturally related industry to acknowledge industry's responsibility in such research and to assume that role.

Member Companies

The strength of the Institute is derived from the staunch support of its member companies. When API was established in 1935, the members were:

American Potash & Chemical Corporation — producing from brines in California

Potash Company of America — mining at Carlsbad, NM

United States Potash Company — mining at Carlsbad, NM

N.V. Potash Export My — representing the European producers

Later other Carlsbad producers joined API as they came into production. During the 1960's potash production began in Canada and also in Utah. Some of the Canadian producers were already members of API. Most of the new producers in Canada and Utah joined.

When the phosphate producers joined the Institute and it became PPI, this was reflected in many new members.

Special recognition should be accorded to the one company that was a charter member in 1935 and has remained a loyal member throughout the 50 years of the Institute. That company is **Potash Company of America.**

Staff

The Institute has never wavered from its conviction that cooperation with official agricultural agencies was and is the sound approach.

The staff has always been selected with extreme care — so as to consist of those whose training and experience enable them to work closely with their counterparts in the universities, to assure that information in all matters is based on scientific evidence and the farmers' welfare.

Dr. Turrentine

Dr. Mann

Dr. Reed

Dr. Wagner

In its 50-year history, the Institute has had only four presidents:

Dr. J. W. Turrentine	**1935-1948**
Dr. Harvey B. Mann	**1948-1963**
Dr. J. Fielding Reed	**1963-1975**
Dr. Robert E. Wagner	**1975-**

Each of these men, when appointed president, had an outstanding reputation and record of accomplishments, and each remained as president until retirement.

From its beginning the Institute located its technical staff in the areas of fertilizer use, usually at a university site. In 1935 they were in 16 locations throughout the U.S. and Canada. This policy is still followed. The present regional directors (12 in number) are men with advanced education and training who work closely with local agricultural leaders.

The International staff and program are a very important part of the Institute's history. This is another story and is discussed elsewhere in this issue.

The member companies have always been proud of the staff. Reflecting over the 50-year history of the Institute, three factors stand out:

(1) The adherence to sound proven principles.

(2) The competence and reputation of the staff.

(3) The unwavering support of the member companies.

These should carry the Institute through another 50 years. ■

Agronomic Programs in North America for 50 Years

By Werner L. Nelson

THE INSTITUTE was founded with the goal of increasing the use of K in agriculture on a basis agronomically sound and profitable to the farmer. The Institute research and education programs along with efforts of others have left their mark on yields and fertilizer use.

Crop yield increases have been phenomenal and there is much more to come.

Highest U.S. Average Yields Per Acre

Crop	To 1935	To 1985
Corn (bu)	28	113
Wheat (bu)	16	39
Soybeans (bu)	17	32
Alfalfa (tons)	2.1	3.4
Cotton (lb)	213	610
Peanuts (lb)	627	2,918

N, P_2O_5 and K_2O use increased sharply but the sharp upward climb stopped in the late '70's to early '80's.

Staff

The agronomic staff has been the key to success. Members have been well grounded in soil and crop sciences, in crop production, and in the multidisciplinary approach. They are located out in the regions and have frequent contact with extension, research, teaching, industry, farmers and the media. While publications, research funds, and education tools are all important, the key effect of the staff is through this one-on-one contact with people, to get on their team. Planting ideas and then waiting for germination, growth and fruition have been the major course of action.

With a relatively small staff, it has been important that their efforts be magnified through agricultural leaders. The staff has the advantage of seeing many people, projects and farmer and dealer efforts. This provides for hybridization of ideas to be passed along to the thought and action leaders.

Major approaches over the years

To get the facts — through research
To show the facts — through demonstrations
To tell the facts — through publications, visual aids, talks, exhibits, media
To sell the facts — through dealers, member companies, extension, diagnostic approaches, fertilizer associations

To get the facts — research

Funds have been provided over the years to help defray the cost of conducting experiments and particularly in the early years, to support graduate students. Equally important as the funding, have been the ideas and physical assistance given to the researchers by PPI staff.

- **Diagnostic techniques.** Much effort was given to research on calibration of soil tests and plant analyses in the '30's and '40's. This resulted in soil test services being established during this time in every state east of the Mississippi River plus other states. Available K, as contrasted to total supply of soil K, was studied. It was pointed out that K release from insoluble minerals by weathering was too slow to provide a crop's requirement during the growing season. Chemists devised "availability tests"

Dr. Nelson is Senior Vice President of the Potash & Phosphate Institute.

and calibrated them. Field, greenhouse and laboratory studies were involved. Dr. Roger Bray was foremost in this early work. Dr. G. N. Hoffer, first Midwest Manager for the Institute, pioneered with corn stalk tests in 1923.

- **High yield corn experiments.** Dr. George Scarseth and his graduate students at Purdue were instrumental in putting together better hybrids, higher rates of N, plant population, phosphate and potash to produce higher yields of corn in the 1940's and 1950's. Dr. George Hoffer and H. L. Garrard, Institute Agronomists, were key parts of the effort. The work spread to other states including North Carolina where Dr. B. A. Krantz conducted experiments. Average North Carolina corn yield went from 23 bu in 1943 to 35 bu in 1949.

- **Fertilizer placement.** The analysis of fertilizer used at planting increased, particularly in K_2O, 2-12-6 to 3-12-12, 0-20-20, 0-10-20 and 0-9-27, and this necessitated more attention to placement. Much work was done on 2 x 2 placement, two inches to the side and two inches below the seed, in crops such as cotton, soybeans and peanuts in the South and corn and vegetable crops in the Midwest and East.

  Plowdown of 800 to 1000 lb of grades such as 10-10-10 for corn started the trend to broadcast of heavy rates of mixed grades and muriate of potash. Rates of 200 to 300 lb of muriate per acre became common for corn in the 1960's and '70's.

- **Potash needs of forage crops.** Through plant analyses it was learned that forage crops removed high amounts of K. Alfalfa was a prime target and F. E. Bear, New Jersey, Richard Bradfield in New York and C. J. Chapman in Wisconsin

(continued on next page)

were key researchers. Boron, P, K and lime levels were a part of the studies. Plant analyses, nutrient ratios and control of leafhopper were important considerations.

- **Plant food utilization.** Total uptake of N, P_2O_5 and K_2O in the aboveground crop, harvested plus unharvested, has been emphasized ever since 1935. While it is not an indication of the amount of fertilizer needed, the figure calls attention to the amount of nutrients taken up by high yields and which must be supplied by the soil, manure or fertilizer. The first chart on 20 crops came out in 1940 with yields such as corn 60 bu, soybeans 25 bu, wheat 30 bu and alfalfa 3 tons. Charts were updated over the years. In 1979 Mg and S uptakes were added and three levels of yields were used: corn up to 250 bu, soybeans 80 bu, wheat 100 bu and alfalfa 10 tons.

- **Interactions.** In the '30's and '40's the effects of K in reducing lodging and improving quality of grain crops were reported by the Illinois Experiment Station. The effects on reducing cotton wilt was demonstrated in the South. The influence of K in reducing stalk rot of corn and the importance of balanced plant nutrition, particularly with N, has been a continued effort over the years.

  In the '60's, '70's and '80's increasing emphasis was placed on having all crop production inputs such as variety, plant spacing, lime, cultural practices and pesticides in adequate supply to get the most return from N, P and K, labor, land and machinery inputs. This, of course, is directly related to the multidisciplinary approach.

- **Economics.** The economics of potash use has been considered from 1935 and top profits in the total production system was an important part of the selling job. Later this was broadened to the term " top profit" and then "maximum economic yield" (MEY). The latter is predicted by rates of inputs in maximum yield research. Much remains to be learned about the rates of inputs needed to establish MEY but it is an excellent concept. Regardless of crop prices it is essential that the farmers aim for MEY. This gives the lowest unit cost of production and the highest profit (or least loss).

- **Maximum yield research.** In the late '70's the need was recognized to establish maximum yield levels for given soils and climates. Multidisciplinary research was intensified and under irrigated conditions yields up to 338 bu of corn, 118 bu of soybeans and 182 bu of wheat were obtained. Ten ton yields of alfalfa were obtained unirrigated and 24 tons with irrigation. A 241 bu/A 3-year average of corn in Ontario (unirrigated) was obtained.

  Funds spent for research have increased markedly. In 1970, the total budgeted for research was only $5,700. By 1975, the figure was $25,000, and by 1980 it increased to $250,000. In 1985, the combined research budget for PPI, FAR, and the special China program is over $1 million. Research is done by state and federal workers and, hence, the results have their blessing.

- **Fellowships.** Up to about 1970, research funds were widely used to support graduate students. This training of future leaders has been an essential part of agronomic progress. Many of the people now in leadership and prominent positions were once potash fellows. In recent years grants have been made directly to selected top-notch graduate students with no duties required.

To show the facts — demonstrations

"Seeing is believing." Farmers like to see what happens on their farm or in their area. Demonstration of the effect of K was used heavily in the early years and in the period 1935-1945 the Institute compiled a record of 31,560 demonstration years. In this same period in the South it

was estimated that demonstrations were inspected by 363,000 people. In recent years demonstrations have not been used as extensively but they still have a place in revealing superior crop production practices, either singly or as a package. Demonstrations can be used to show the benefits of established practices or the need for further experimental work.

Large tonnages of potash have been donated to extension, research, teachers, SCS, TVA and other agricultural agencies. Details of the demonstrations are the responsibility of the state and federal workers and, thus, the results obtained bear the official stamp of the agencies they represent.

To tell the facts — publications, visuals, talks, exhibits, media

The hallmark of Institute releases has been simplicity, directness and a message tailored for the audience. The releases have been based on scientific papers, which contain facts on how the research was done, detailed results and interpretation. Farmers, industry, research and extension all appreciate simplified presentations from which facts can readily be grasped.

There have been a number of cornerstones of Institute publicity.

Publications

Better Crops. A periodical made up of short, educational pieces or reports on research, largely by official agriculture, was started in 1923 by the NV Potash Export My. This is sent widely to official agriculture, industry and other thought leaders. Reprints of articles have been distributed by the thousands.

Newsletters were first made up of short news items and evolved to a topic basis. The first one on a topic basis was on soil testing in 1956. A series of special topic publications called **Agro-Knowledge** began in 1977.

News & Views started in the '70's. Each is prepared by the regional directors on key issues of interest to industry and others.

Folders on appropriate subjects of use to industry and farmers have been prepared by Institute staff. Series on plant food uptake and economics are examples. Hundreds of thousands of these have been distributed.

Wall charts. Educational charts have been popular, starting with Plant Food Utilization, Corn Starvation Symptoms, Cotton Rust Is Potash Starvation, and Potash Starved Legumes. Since then Soybeans Get Hungry Too, Fall-Winter Fertilization, and Crops Take Up Nutrients in All Seasons have been released.

Books

"Potash Deficiency Symptoms" Eckstein, Bruno and Turrentine. 1937.

"Hunger Signs in Crops" ASA and NFA. 1940.

"Diagnostic Techniques for Soils and crops." 1948.

"The Role of Potassium in Agriculture." 1968.

"Potassium in Agriculture."ASA 1985.

(continued on next page)

Root studies

The effects of fertility and lime on extent of root growth in corn, soybeans, wheat and alfalfa were shown dramatically in the '50's and '60's through H. L. Garrard's root washing technique. Cover photos and articles appeared in *Better Crops* and elsewhere.

Visual aids

Color film was developed for widespread use in the 1930's and this tool opened up a new field for showing crop responses and nutrient deficiency.

Movies. Twenty-one movies were produced in the first 25 years – shown to some 5 million people. The most notable was the **Plant Speaks Series** in 1944 covering soil depletion and K deficiency symptoms, soil testing, plant tissue testing and leaf analysis. **New Soils from Old, Growing Alfalfa Successfully, and Potassium in Soils and Plants** were key movies.

Slide sets. Colored slides provide an excellent record of crop development and each agronomist is equipped with a camera. H. L. Garrard was an outstanding agronomic photographer and he pioneered the practice of furnishing slides to cooperators, media and industry. The first attempt to put key slides into a set along with a script to tell an educational story was in 1956 with "Successful Alfalfa-You Can Grow It." This was the first of a series of slide sets ending up with some 30 sets in 1985.

Talks

The Institute staff members often appear as speakers in crop production meetings. Seldom is there such a meeting when an Institute representative is not on the program. The key to success has been objectivity, talks tailored for the audience, recent information and good visuals.

Exhibits

Displays which tell the story of Institute approaches are a center of attention at various types of meetings. Examples are:

Do your crops have hidden hunger? 1958.
What's wrong with my crop? 1960
Visual aids sell fertility – 1963
Research and education. PPI and FAR – 1982.

Media

Farmers read farm magazines and newspapers and dealers read trade publications. Articles by staff, personal contacts, suggestions and news releases have helped to get this important group on our team. Second, third and even fourth generation use of Institute information is obtained. A sympathetic press is essential.

To sell the facts through leaders and the diagnostic approach

With only 15 staff covering North America it has been essential that their efforts be magnified. This is done through personal contacts and training aids to be used with and by the leaders in their own educational programs. Two key examples are the manuals. Some 32,000 of the **Soil Fertility Manual** and 8,000 of the **Maximum Economic Yield Manual** have been sold. These come complete with slide sets and have been widely used in dealer training meetings and for farmer groups.

Diagnostic approach. One of the important activities of Institute staff has been to get out in the field with research, extension and industry co-workers to observe and study what might be limiting yield so that it could be even higher. This demands that all phases of crop production be considered. In 1962-3 at the Brownstown Soil Experiment Field, Illinois, a series of workshops was held separately for extension, research, seed corn agronomists, fertilizer industry agronomists, and farm managers. Tools were the Hoffer soil profile sampler, tissue tests, pH tests, history forms and checklists.

Research roundtables and workshops. A major function of the Institute is to be instrumental in bringing people together to exchange ideas. Research roundtables were started in earnest in 1958 and have evolved into maximum yield workshops.

Member companies. Personal contact with the salesmen is essential. In 1957 meetings with potash salesmen were initiated to keep them abreast of agronomic developments and fertilizer use trends. Institute staff members supply publicity

materials and appear at member company sales meetings. Recently meetings have been held for member company and FAR donors every two years and the entire domestic staff appears on the program. Statistics on K_2O sales have been issued since 1937 and since 1983 similar information has been prepared for P_2O_5.

Fertilizer associations. State and provincial associations provide a platform for industry and official agriculture to get together to discuss common problems and solutions. The Institute staff has served in organizations, as officers, in planning and on programs. Too, the staff serves in many capacities for organizations such as NFSA, TFI, and AFGC and state forage councils.

The staff was instrumental in starting extension-industry agronomist soil fertility workshops in the Midwest in 1971, the South in 1973, the East in 1977, the Great Plains in 1980 and Ontario in 1984.

What does the Institute mean to the farmer?

In the final analysis the big question is what research and education activities contribute to crop yields and farmer profits. The Institute has endeavored to unlock the secrets of what first K, and then starting in 1977, P and K do in crop production. The relation with other crop production inputs and on profits has been and is being emphasized. The purpose in the future will be to continually search for those practices which will increase crop yield — to find the next limiting factor. This is what maximum yield research is all about.

By definition maximum economic yield (top profit per acre) is the point closest to maximum yield where the highest possible net return is achieved.

Increased effort by research and educational agencies will be required to identify those inputs and rates of inputs which will continue to increase crop yield. The farmer must strive to grow crops for a lower cost of production per unit so that he can better compete. The Institute has much to contribute.

If not now, when? If not us, who? ■

Themes, Thrusts and Approaches

1935 Demonstrations to show the need
Adequate K important in keeping corn conductive tissues (pipelines) open
Profits
1940 Diagnostic techniques to identify needs
Plant food utilization
Fertilizer placement for efficiency and safety
1941 Hunger signs in crops
1943 Potassium need maps
1945 Soil aeration and compaction
1947 Do your crops have hidden hunger?
1952 Root studies to see what is under our feet
1955 Soil fertility diagnostic score card
1956 Safe and efficient fertilizer placement
1960 What's your next limiting factor?
What's wrong with my crop?
1962 Changeable letter signs
1963 Visual aids sell fertility
Moisture and fertility
1964 Plan for full feed
Fight hidden hunger with chemistry
1965 Facts point to fall-winter fertilization
More N means more K-NK balance
1966 Fight disease with plant nutrients
1968 Look back to plan ahead — a diagnostic approach to top corn yields
A quantity of quality
1969 P and K add muscle to N
1974 High P and K soils
1975 Agro economics
1976 Fertility fights crop stress
Key factors affecting crop response to K
1977 Interactions and the multidisciplinary approach
1978 Maximum yield research for maximum economic yields
1979 Multiple cropping and fertilization
Key factors affecting crop response to P
1980 Fertilizer increases energy efficiency
Maximum yield farmer clubs
1982 Conservation tillage and fertilization
MEY systems — how they work for water use efficiency
1983 Maximum economic yield systems — how they work for conservation
1984 The diagnostic approach intensified
High yields — a deterrent to erosion

Better Crops with Plant Food: A Look Back from 1923-1985

By Santford W. Martin and Noble R. Usherwood

WHEN THE NEWLY FORMED American Potash Institute acquired *Better Crops with Plant Food* magazine in 1935, the magazine was about to celebrate its 12th birthday. It was first published in September, 1923, by the Better Crops Publishing Corporation of New York City, a subsidiary of the Potash Importing Corporation of America. It was known as the pocket book of agriculture.

SHOWN at left is the cover of the first issue of *Better Crops*, September 1923. At right above is the cover of the first combined issue of *Better Crops with Plant Food*.

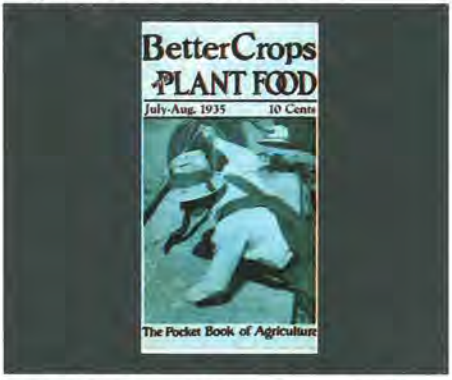
In 1927, when the German and French potash interests merged, the two magazines—*Better Crops,* founded in 1923, and *Plant Food,* founded in 1926—became one, published by the Agricultural and Scientific Bureau of N. V. Potash My of Amsterdam, Holland.

From September, 1923, through June, 1927, the magazine was a 4 ¾ x 7 ¾ inch format. The July, 1927, issue was the first 6 x 9 inch format. It has remained that size for well over a half century now—and is still known as the pocket book of agriculture.

In July, 1935, the new Institute's magazine stated an editorial policy the journal has carefully practiced for a half century:

"The policy of *Better Crops with Plant Food* is to stimulate interest in all factors pertaining to more efficient crop production and to give accurate information on such subjects. In developing more efficient agriculture, we believe one of the most important factors is sound research and experimental work.

"It is our policy, therefore, to support all groups and agencies doing such work, especially the State Agricultural Experiment Stations and Colleges and the U.S. Department of Agriculture.



THE FIRST issue of *Better Crops with Plant Food* published by the American Potash Institute, Inc. was July-August 1935.

"We believe such research work is of greatest value when translated into more efficient production and better living on the farm. Agriculture should be put on a business basis. The farmer is entitled to a larger share of the consumer's dollar. One sure way of getting it is to cut the cost of production.

Mr. Martin has served as an Editor for the Institute since 1957. Dr. Usherwood is Vice President for Member Services and Communications, Potash & Phosphate Institute.

"Consequently we heartily support the work of the agricultural extension forces and the county agricultural agencies working to that end. Especially do you want all the facts, not selected facts. It is a vital policy of *Better Crops with Plant Food* to publish all the facts.

"And you want these facts presented by authorities in an easy-to-read and attractive form. To combine a soundness of purpose with brightness of treatment is one of our aims. This magazine is your forum."

Hundreds of Articles, Authors, Crops

And that's exactly what *Better Crops* has been—a forum for official agriculture. Under the Institute's 50 years of management, this magazine has featured more than **2,800 articles** written by more than **1,270 authors**. Many authors contributed more than once, some up to a dozen or more articles.

BC authors have come from 6 major categories over the years: (1) USDA leadership, (2) Experiment Station scientists, (3) Extension Service specialists, (4) SCS technicians, (5) Extension and USDA editors, (6) scientists and specialists with private enterprise.

But more than crops have been featured. People, ideas, trends, statistics (agronomic and economic), reviews, editorials, human interest columns, and jokes have all been popular features.

A Profound Love for Truth

The *Better Crops*-kind-of-author was best described in an issue just 18 months after the Institute was founded:

"A scientist is not necessarily some mystical being who 'talks big words' on some 'theoretical' subject. Rather, a scientist is one of millions who does good things well and seeks to do them better.

"A scientist is any person who observes accurately and checks continuously both his observations and his means of observation. He endeavors to improve his knowledge of his vocation, or avocation, or aught else to which he gives attention, by planning and executing true experiments in which all conditions are the same and under his control, except the one condition whose appearance will yield the unknown answer to be determined by the experiment.

"He respects both the theoretical and the practical. He seeks to distinguish facts from opinions. Yet he knows that whereas facts are beyond change or compromise, the perception of them may be inaccurate, the interpretation of them is often ephemeral and, in any event, subject to change. He aims to express his knowledge in quantitative or at least definite terms. He knows that all truth agrees.

"Thus, the true scientist not only possesses accurate knowledge, but he holds a mental attitude of open-mindedness and modesty, of progress and improvement, and of profound love for truth." ■

Articles Into Chain Reaction

Out of more than 2,800 articles featured in *Better Crops* over the past half century, approximately 1,150 have been converted into reprint-folders—with the folders in a few instances produced first and then run in BC. One of the most popular groups has been the **plant food uptake** series.

- **Know Plant Food Content of Crops.** A milestone classic first produced in March, 1940, by the late J.D. Romaine. It featured the pounds of nitrogen (N), phosphate (P_2O_5), and potash (K_2O) contained in total plant with good per-acre yields of 20 major crops.

  From this approach grew the Institute's widely requested Plant Food Uptake series of individual folders on **corn, soybeans, alfalfa, wheat,** and **sorghum** plus the popular **PFU wallet booklet.** Total distribution of these PFU items **after their appearance in** *Better Crops* has been more than 2 million copies to date. ■

Memories from a Past Era...

IN ADDITION to its regular agronomic articles on the development and management of all kinds of crops on all kinds of soils under all kinds of conditions, *Better Crops* featured some interesting briefs over the years. Some examples from the mid-1930's to the mid-1950's give a new perspective on a past era.

- **A soil testing train** on the B&O railroad ran from the western side to the eastern side of Indiana in the 1930's. During the 2 weeks tour, nearly 1,300 farmers registered for lectures and 950 fertility tests and 1,500 lime tests were made. Many soils showed great need, as recommendations were given by the Purdue scientists.

- **The spring dust storms** of the mid-30's became what one author called "an almost annual affair." Writing a piece called "Controlling Soil Erosion in Northern States," the Cornell author said the work of the wind is "more spectacular than that of water, **yet the latter is highly destructive."**

- **A fascinating point to ponder** appeared in BC just after America's victory in World War II. It said, "If the 1934-35-36 dry weather cycle (of the awful dust storms) had been delayed another 10 years, to occur during the war, we and our allies would have found it very difficult, if not impossible, to have won the war."

- **The impact of wartime on agriculture** was seen like this in 1946: "One of the amazing things...is that American farmers are today producing a **third more products** for market than they did before the war. And they have been doing it with 10% fewer workers and very little increase in land used."

- **Secretary of Navy James Forrestal** saluted American farmers this way in the October, 1946, *Better Crops*:

  "In September, 1945, the Japanese surrendered. I regard it as significant that they surrendered during the harvest month, for, no less than the guns and the spirit of our men and women, it was the food which came from the great farming areas of this country that brought us victory."

- **The importance of food for the war** and any other time was perhaps best summed up in one sentence by Dr. George R. Minot, Harvard School of Medicine, speaking in a 1948 *Better Crops*:

  "Initiative, progress, success, and the happiness of a people tend to go hand in hand with an abundance of food and a good diet."

- **Soil Mining or Soil Building?** The question always seems fresh to each generation. Wisconsin's brilliant communicator, the late C.J. Chapman, warned in *Better Crops* in 1937:

  "Wisconsin farms are losing fertility at an alarming rate. The average Wisconsin dairy farm is losing phosphorus and potash at a rate equal to 1 ton of 20% superphosphate and at least 1 ton of 50% muriate of potash each year."

- **Soil and plow meant more than Washington.** In the late 1930's, BC described the big plow Daniel Webster created a century before...12 feet long from tips of handles to tip of beam...with a 15-inch wide share... designed to turn a furrow 12 to 14 inches deep...requiring 8 oxen to pull it.

  A firm believer in deep tillage, Webster said, "When I have hold of my big plow...in a brush covered pasture and hear the roots crack, see the stumps go under the furrow out of sight, and observe the clean, mellow surface of the land, I feel more enthusiasm than comes from my encounters in public life in Washington."

- **The size of an acre?** An acre is an acre. Nope. It's more than that, according to a 1937 *Better Crops*. The size of an acre depends on the man who works it. The yardstick of an acre is what it will produce. And what it will produce is governed by the man who farms it.
- **A profitable partnership.** Federal Extension Director M.L. Wilson said in a 1941 *Better Crops*, "It is no exaggeration to say the partnership of the county agent and country newspaper editor has within the past 30 years brought about a revolution of farming methods."
- **What does a farmer do?** The Selective Service Boards wanted to know as they drafted young men for the Korean War. And *Better Crops* featured the Labor Department's version of the farmer's chores that went to those draft boards of 1951.
- **Corn needs man as much as man needs corn.** One year after the Institute was founded, *Better Crops* reported students of genetics in USDA called maize, or Indian corn, "the most completely domesticated grain, quite incapable of maintaining itself without man."
- **The third president of the United States,** Thomas Jefferson, was a practical farmer. So said *Better Crops* almost 50 years ago. He knew the importance of soil conservation.
- **A question as new as this morning's sun.** Should the use of commercial fertilizers be included in plans for soil conservation? The founder of the U.S. Soil Conservation Service, Hugh Hammond Bennett, answered this question 45 years ago in *Better Crops* this way:

  "As a result of research by this agency, it is now generally recognized that soil fertility is one of the first essentials of effective soil conservation. . . SCS found that the use of commercial fertilizers in a corn, small grain, clover-grass rotation resulted in a marked decrease in soil loss from erosion."
- **The first patent issued by the United States government** was for the production of potash or pearl-ash, as it was called in 1790, from wood ashes, *Better Crops* reported almost 3 decades ago. ■

Signed Off With Laughter...

For many years, *Better Crops* included a page of jokes, called WHINNIES—a very popular feature. Of interest to this 50th PPI Anniversary issue are the kinds of jokes that appeared a half century ago:

A farmer visited his son's college. Watching students in a chemistry class, he was told they were looking for a universal solvent.

"What's that?" asked the farmer.

"A liquid that will dissolve anything," he was told.

"That's a great idea," agreed the farmer. "When you find it, what are you gonna keep it in?"

***Lifeguard** (with girl in arms): "Sir, I have just resuscitated your daughter."*
***Father:** "Then, by gad, you'll marry her."*

A school teacher, trying to impress her class with the destructive effect of alcohol, procured two earth worms, one of which she dropped in a bottle of alcohol and the other into a bottle of water.

Next day the worm in alcohol was dead. The one in water was still alive.

"Now, children," she said primly, "you see what happened here. What do you think alcohol does to a man?"

Silence and deep thought set in. At last one youngster said, "Well, he wouldn't have worms, that's for sure."

Special Themes by A

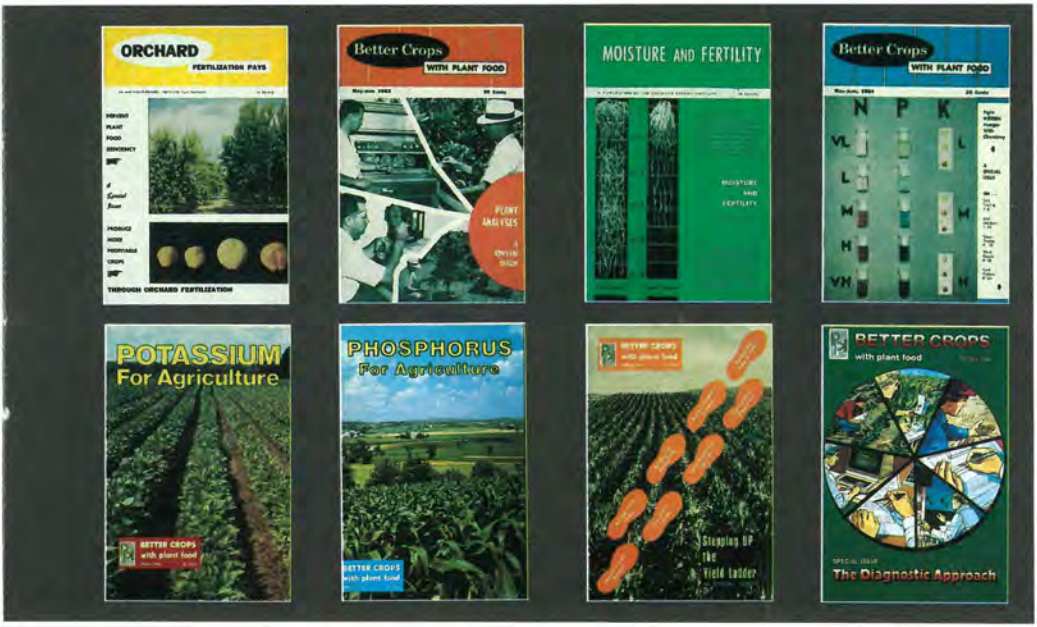
In July, 1957, *Better Crops* introduced
specials between 1957 and 1984. These iss
by authorities in the subject field. More t
have been distributed as booklets over and

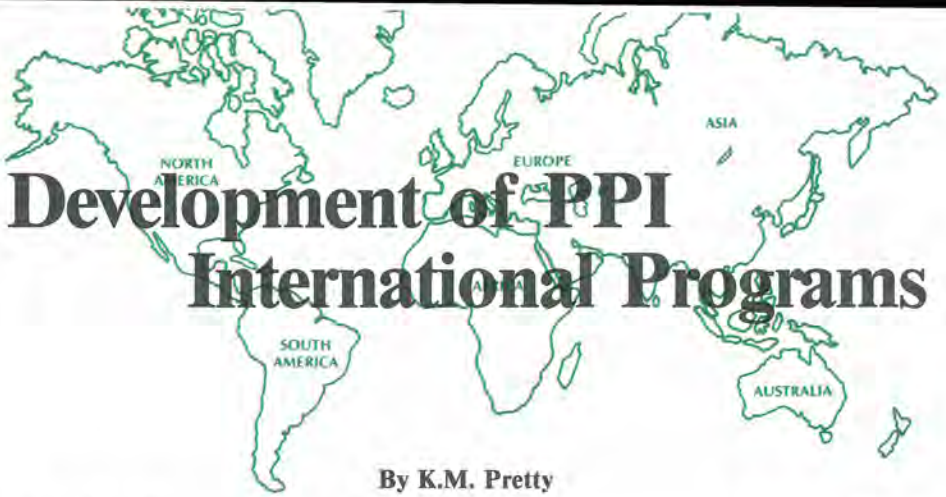
- **FERTILIZER PLACEMENT, 1957.** As rates and analyses of fertilizers for crops are increased, proper placement becomes more and more vital.
- **HIDDEN HUNGER, 1958.** External hunger signs may disappear while the crop does not have enough nutrients to tap its top potential.
- **FOREST FERTILIZATION, 1958.** Many specialized situations showed fertilizer needed and profitably so.
- **YOU CAN GROW A GOOD LAWN, 1959.** General principles booklet. How to determine lime and fertilizer needs. Nine steps to a good lawn.
- **YOU CAN GROW A GOOD GARDEN, 1959.** General principles booklet, on making shrubs more hardy through nutrition...menu for home vegetable garden...ornamentals as route to colorful landscape...growing and fertilizing shade, ornamental, and fruit trees.
- **LIMITING FACTORS in CROP PRODUCTION, 1960.** Looking at factors affecting crop production—soil physical traits, nutrients, variety or hybrid, insects, water, weeds, plant diseases, and corn stands—how to use and control them for maximum yields.
- **FORAGE FERTILIZATION PAYS, 1960.** Featuring forages from all over the nation. Profit potential from properly fertilized forages.
- **ORCHARD FERTILIZATION PAYS, 1961.** Importance of fertilization—right kind at right time in right place in right amounts—for more plus better quality peaches, apples, citrus, cherries, etc.
- **PLANT TESTING, 1962 and FIGHT HIDDEN HUNGER with CHEMISTRY, 1964.** Two issues on plant and soil testing as good research and educational tools to help farmers ask the soil, the leaf, and the plant for their crop's nutrient needs and the road to maximum economic yields.

Authoritative Authors

its first **special issue** that would lead to 19
ues have featured major subjects explored
han 800,000 copies of these special issues
above the magazine's regular circulation.

- **MOISTURE and FERTILITY, 1963.** Fertilization may increase root exploration of the soil, using water to higher tensions and greater depths, helping crops produce more per inch of water.
- **USE N-K TEAMWORK, 1965.** Documented how high N use was increasing potash needs of crops.
- **IS YOUR CROP GO? FIGHT DISEASE, 1966.** In a day when plant diseases cost the American farmer an estimated $3 billion a year, scientists were reporting nutrients help reduce diseases.
- **BUILD CROP QUA-N-LITY WITH K, 1968.** Documents potash effect on quality of 14 crops—from improving health of soybeans and feed value of corn grain to improving taste of canned peaches, plumpness of rice, strength of cotton, extra cut of alfalfa, etc.
- **Two POTASSIUM for AGRICULTURE specials, 1973 & 1980.** Updating booklet first issued in 1956, revised twice in 1960's. How and where K produced. How K works in plant functions and uptake. . . on crop yields and drought resistance. . . in fertilizer placement and starter. . . on fixation, crop maturity, disease resistance, and quality. . . in economic returns.
- **PHOSPHORUS for AGRICULTURE, 1978.** This issue and the 1980 potassium special approached the subject of their respective nutrients in similar styles.
- **STEPPING UP THE YIELD LADDER, 1979.** Looks at how vital maximum economic yields are to modern farmer. Some 20 reports show importance of interactions in today's farming. . . not just balanced nutrition. . . but total system. . . variety, insect-disease control, population, tillage, etc.
- **THE DIAGNOSTIC APPROACH, 1984.** Discusses how to become a complete diagnostician. . . how visual symptoms can indicate plant disorders. . . how to interpret soil tests and make recommendations from them. . . how to use plant analysis. ■





Development of PPI International Programs

By K.M. Pretty

FOR THE FIRST QUARTER CENTURY of its existence the American Potash Institute (now PPI) concentrated its research and education programs in North America. Rapid expansion in potash production in Canada during the 1960's made it abundantly clear that new international programs were needed if markets for potash fertilizers were to expand in a reasonable time span.

Programs were initiated in a number of countries including Australia, Brazil, Central and Northern Latin America, Southeast Asia, Japan and South Korea, in cooperation with the International Potash Institute.

Fertilizer use in many of these countries was characterized by low demand for all nutrients, and inadequate research to establish the most appropriate rates of application. Similarly, crop yields were very low so that many soils could supply sufficient K to support these low yield levels.

The research and education efforts were aimed at getting the first pound or kilogram of K used in regions where it was unknown, or to establish the need for greater amounts when combined with improved production practices. With the facts in place through research, this information could be packaged in a form useful to extension workers, the fertilizer industry, and the ultimate beneficiary — the farmer.

The Green Revolution of the mid-1960's provided a new focus for program intensification. Higher yielding varieties were more responsive to the use of inputs, especially nitrogen. The increased use of N, and greater crop removal of soil nutrients by higher crop yields, accentuated P and K deficiencies. The "package of practices" concept so ardently promoted by national and international organizations in that era can be interpreted as a forerunner of the Maximum Economic Yield (MEY) philosophy that is now prevalent in both developed and developing countries.

PPI's international programs have assisted in the development and adaptation of technologies appropriate to each country or region, as well as to smallholders producing food crops and commercial, export crop sectors. Since its inception 25 years ago, PPI has supported the worldwide program of fertilizer trials and demonstrations carried out under the FAO Fertilizer Programme, with technical and financial assistance from the fertilizer industry.

It has frequently been stressed that fertilizer need does not equal demand. Nowhere is this more evident than in developing countries. The benefits of N fertilization are quickly apparent to farmers so that demand for this nutrient far outstrips

Dr. Pretty is Senior Vice President, International Programs, of the Potash & Phosphate Institute (PPI).

the use of P and K. PPI has encouraged the establishment of long-term experiments to examine the most appropriate nutrient balance for sustained production.

With sharply higher N use in many developing countries, better varieties, and other improved production technologies, it is apparent that the use of P, K, secondary and micronutrients must likewise increase if the momentum of higher yields is to be maintained. Imbalanced nutrient use threatens future production gains in a number of countries, including China, where the existing $N:P_2O_5:K_2O$ ratio is approximately 1.0:0.27:0.05.

The Future

PPI has expanded its international programming significantly in the past several years, and even greater expansions are contemplated in the near future.

Although programs have been carried out in China and Southeast Asia for several years, these were given further support by the addition of one agronomist for each region in 1985. New programs are under consideration for Northern Latin America and South Asia. The North American-based staff involved in the implementation and coordination of international activities is also being strengthened in 1985.

Support for Maximum Yield Research (MYR) and the establishment of MEY cropping systems are in the forefront of these new and expanded programs. Similarly, educational activities such as publications in local languages, audiovisual aids, seminars, conferences and workshops play key roles in moving new technologies into practice as quickly as possible, and keeping agricultural leaders up to date on the potential for increased crop output. The personal services provided by PPI agronomists in putting new research projects into place, in monitoring the progress of this research, and in disseminating results to agriculture departments, the fertilizer industry, and ultimately the farmer form the backbone of all programs.

Although the most obvious beneficiaries of expanded fertilizer use are the producers of basic materials, fertilizers can rightfully be called instruments of rural development. As yields increase, employment is created in the transportation, storage, distribution and marketing chains, both for the surplus commodities to be sold by farmers and in the supply of inputs. Through taxation, government revenues are improved for investments in a host of projects for economic and social development in their countries.

As rural and urban incomes are increased through greater economic activity, diets also change. Usually this takes the form of a greater demand for animal and plant protein, and more variety in all foods. Data show that developing countries which have increased their agricultural and economic activity at the fastest rates in the past one or two decades have likewise expanded agricultural imports much more than the least developed countries.

Most forecasters agree that developing countries will use an increasing proportion of all fertilizers between now and 2000. It is unlikely, however, that the targets established by such international bodies as FAO can be met without massive efforts to remove the many agronomic, economic, social and institutional constraints to fertilizer use that exist in many countries.

Many of these constraints must be tackled by governments themselves, assisted by a number of international agencies. For its part, PPI will continue to focus attention on the first two of these constraints – agronomic factors which limit crop yields and the efficient and effective use of fertilizers, and the economic benefits to be derived from a balanced plant nutrition program in diverse soil and climatic environments. ■

Foreword

PPI'S INVOLVEMENT is broad. It reaches various aspects of leadership in agriculture, including research, extension, teaching, industry, government, farm managers and bankers, administrators, and, through all of these, the farmer.

This section includes comments from recognized leaders in some of these areas, reflecting their views of PPI's role over the years and in the future. ■

Advisory Council View of PPI's Role

By Marty Thornton

PPI'S FIFTIETH ANNIVERSARY warrants a thorough view of the contributions, research and education that have become commonplace with many progressive fertilizer dealers, growers, lenders, extension personnel, farm managers and consultants.

Upon reflecting to the 1930's when PPI was founded, one immediately thinks of the "Depression" days and "troubled times" on the farms of America. We don't know what the attitude of the PPI founders was in those early years, but it seems evident from the success that it must have been one of 1) innovation, 2) optimism and 3) determination during a time when pessimism was widespread. Major achievements have been advanced to agriculture by concentrating on the efforts of **research and education**. Examples of PPI efforts are easily seen in the farm media. In the United States, 300 bushel corn and 100 bushel soybeans have been achieved several times directly through PPI sponsored maximum yield research. On the international front, cultural barriers in Asia and South America have been bridged and people in those countries are increasing production levels and improving their diets.

Emphasis in the '80s on combining the "economics" with maximum yield research have once again positioned PPI correctly at just the right time to assist "financially stretched" farmers. MEY research is focusing on **profitability** of the farming enterprises at a time when growers must have that information to insure survival in years to come.

I see PPI as "conservatively creative"; solid and stable yet innovative and progressive. The PPI leadership and staff have selected and coordinated outstanding research efforts which are pointing toward future accomplishments. These current efforts are building on the "solid fifty" years of achievements.

Mr. Thornton

The PPI staff is motivating and challenging: 1) themselves, 2) growers, 3) agricultural lenders, 4) fertilizer dealers, 5) extension personnel and 6) farm managers and consultants with both technical and fundamental agronomic information. They are prepared to weather the economic storms of the eighties and nineties just like those they handled so effectively at PPI's formation in the thirties and forties. ■

Mr. Thornton is Vice President and Senior Farm Manager, Peoples Bank of Bloomington, Illinois. He is 1985 Chairman of the PPI Advisory Council.

University Administrator's View of PPI

By E.T. York, Jr.

I AM DELIGHTED to join in this Golden Anniversary celebration of the Potash & Phosphate Institute. This Institute and its predecessor organization, the American Potash Institute, have made most significant contributions to the advancement of agriculture in North America and, increasingly, in other parts of the world.

The Institute is unique among industry related organizations. It has never been a "blind" advocate of the products of the industry from which it derives its support. Instead the Institute has consistently supported the development and advocated the application of a total "package" of research-proven farm practices which could be expected to give the highest economic returns to the farmer.

In this regard, the Institute has had objectives very similar to those of U.S. land-grant universities and official research and extension organizations in other countries. These official bodies have been supportive of Institute programs – just as the Institute has supported the programs of these research and education institutions through research grants, graduate fellowships, and related efforts.

The Institute has had a significant impact upon the lives of many professional agriculturalists, including my own. A Potash Institute fellowship made possible my Ph.D. level training and contributed to a lifelong interest in the potassium nutrition of plants. While on the staff of the Institute, my involvement in a survey of global agricultural problems and potentials stimulated my interest in the issue of world hunger and has resulted in my devoting the latter phases of my professional career to this subject. I am deeply grateful for the contributions which the Institute has made to the development and enrichment of my own professional life.

In looking to the future, it is obvious that the Institute has a great opportunity to make meaningful contributions to the solution of the enormous and tragic problems of world hunger. It is estimated that 40,000 people worldwide awake each morning to die of hunger and related causes that day. Current food shortages along with the unrelenting growth in population pose a continuing challenge to agricultural systems worldwide to increase productivity and output.

Nobel Laureate Norman Borlaug recently said: "Without doubt, the single most important factor limiting crop yields on a worldwide basis is soil infertility." Fertilizer use in developing countries is still very low by developed country standards. Significant progress in dealing with the problem of world hunger will demand the use – not only of substantially more fertilizer – but of an array of other improved technologies, including better crop varieties, pesticides, and improved cultural practices.

The concept of maximum economic yields through the application of such a package of improved production practices – as advocated by the Institute – offers great hope not only for addressing the problems of hungry people worldwide but also for improving the plight of resource-poor farmers throughout the Third World. This suggests that never in its 50-year history has the Institute had a greater challenge and opportunity for service than it now has. ■

Dr. York

Dr. York is Chairman, Board for International Food and Agricultural Development, and Chancellor Emeritus, State University System of Florida.

TVA-NFDC View of the Role and Contribution of PPI

By John T. Shields

ON BEHALF OF ALL my colleagues at TVA's National Fertilizer Development Center, I am delighted to join in wishing PPI a Happy Golden Anniversary! You deserve our Best Wishes because you are a partner in and actively contributing to American agriculture. You are a strong force in supporting world food and fiber production.

This broad statement is not made lightly.

Modern agriculture is more than farmers. It is more than support industries, more than universities, more than government. It is, and must be, a synergistic system, embracing all and calling upon all for appropriate contributions.

PPI is an effective part of this synergism, creating and contributing and complementing.

At age 50, you are almost as old as TVA. We were birthed 52 years ago. During most of our organizational lifetimes, we have worked together. This has been especially true in the past two decades.

Over time, our organizations have developed closer relationships and better understanding of each other's goals. The joint TVA/PPI Research Committee has provided an excellent forum for communication. Channels for talking and sharing are critical.

I, and several other members of our staff, have served on your Advisory Council. This has provided us another opportunity to gain a better understanding and appreciation of your interests and to have input in developing that interest for the benefit of agriculture.

PPI's contributions to agriculture are too numerous to mention here. However, I think it is important to emphasize that through cooperative efforts with PPI, I believe Federal expenditures for research and development have been wisely used and cost effective.

Why? Because PPI is committed to bridging gaps between research laboratories and farming operations. This accelerates the acceptance of proven or promising practices. It also helps to weed out the less promising and marginal technologies.

Therefore you emphasize—as we do— research that is practical for the farmer. You are concerned that fertilizer be a "good buy" and that it be used wisely.

I predict a bright future for PPI. I sense that you have every intention of continuing to pursue proven techniques and projects that benefit agriculture as well as exploring new promising concepts.

Mr. Shields

Your Foundation for Agronomic Research (FAR) is just one example of a new impetus for innovative ways to support the kinds of research that are needed by farmers in a rapidly changing environment.

I believe that PPI and TVA have forged a partnership in progress that will continue to generate innovative research and technologies for American agriculture for years to come. We at the NFDC are proud of this relationship. ■

Mr. Shields is Manager, TVA National Fertilizer Development Center.

PPI's Planned Productive Influence

By L.F. Welch

THE THREE LETTERS in PPI remind us of much more than Potash, Phosphate, and Institute. The letters also remind us of the Professional Perceptions and Insights that PPI's staff has encouraged in many growers, scientists, and agribusiness personnel.

Progressive Performance Indefinitely

Those who are even vaguely familiar with the contributions of PPI have a deep appreciation for their role during their first 50 years. The support of the Potash and Phosphate Industries and the leadership provided from both within and outside PPI has resulted in a strong organization. The Institute is now in a Position to Provide Innumerable contributions during the second 50 years.

Plant Productivity Increased

The wealth of all agriculture begins with plant growth. PPI's purpose has been focused around Plant Productivity Increases, and Plant Performance has Indisputably been greatly increased during the past 50 years.

Producer Profits Improved

PPI has forcefully emphasized that increased production efficiency is a vital part of previous successes in crop production. The future economic well-being of producers will surely be closely tied to future advances in crop production efficiency. PPI has vividly proclaimed, through both oral and written presentations, that production efficiency is largely dependent on crop yields per unit land area. Increased production efficiency translates into lower unit cost of production. And lower unit production cost is closely aligned with grower profits.

Permanent Partnership Important

Any one select group is not likely to provide adequate solutions to problems faced by future agriculture. PPI staff is influential. Their persistence and patience have helped identify subject areas that have required further investigation. Through their broad regional, national, and international involvement they have fostered close cooperation among research investigators concerned with soil and crop management.

Pursuing Positive Interactions

PPI recognized the importance of taking advantage of the positive interactions that often occur among plant growth factors. While they may first acknowledge that high and profitable crop yields are impossible with low fertility, they have also zealously promoted management practices that provide other favorable growth factors. These positive interactions exhibited by crops allow returns from inputs to be more fully expressed. Many growers and researchers today are managing better their fields and plots because PPI has sounded the virtues of good overall soil and crop management.

Pertinent Publications Illuminate

The printed word is a hallmark of PPI. Through their numerous publications aimed at growers, industry, and researchers, PPI has effectively summarized and spread valuable principles, concepts, and practices. Slide sets, wall posters, and pamphlets have provided easy amplification of concepts important to crop production. Such materials are always well prepared and effectively convey the intended message.

Dr. Welch

Platinum Philosophy Infused

The services provided to agriculture, and thus to the whole of society, are as valuable as a precious metal is to the jeweler or to an industrial process. PPI has often served as a catalyst that caused other good reactions to occur; much the same as the catalyst platinum. As an eye witness for 30 years, I feel honored to be able to testify to the significant contributions of PPI. ■

Dr. Welch is Professor of Soil Fertility, Department of Agronomy, University of Illinois.

The Fertilizer Industry's Viewpoint of PPI's Role

By W. Scott Tinsman

IT IS FORTUITOUS that PPI is celebrating its 50th anniversary and renewing its commitment of service to world agriculture at this extremely critical moment in our country's agricultural history.

The future structure, viability, and extent of our domestic fertilizer industry will rest to a large extent on the direction our nation's leaders pursue. The key to the successful strategy is the ability of the crop production system to define the methods needed to reach maximum economic yields (MEY), the speed and clarity to which those methods are promulgated and finally the ability of the farmer to implement MEY practices.

Development of proper, complete fertilizer recommendations, and timing and placement of the fertilizer applications are a very important part of this task. The public sector, through its academic and extension research could not, and cannot, accomplish this task without assistance from the fertilizer companies of the private sector. Individual initiatives by fertilizer companies, though helpful in developing limited objectives, are susceptible to duplication, omission, and waste of valuable research dollars. Many small fertilizer producers and retail dealers lack the adequate expertise and resources to conduct research.

PPI and its recent offspring, the Foundation for Agronomic Research (FAR), have represented a most efficient and effective way for the fertilizer industry to support a coordinated agronomic research program. Because of the tremendous number of interactions between all the factors in producing top yields, development of MEY demands research that includes many disciplines.

Research that languishes after the work is completed is useless to the fertilizer industry and the farmer. PPI has played a crucial role in disseminating research results to the fertilizer industry and the farm. Through its publications such as *Better Crops*, Agro-Knowledge and News & Views, complex research work and papers are transformed into useful information which can be further promulgated through the agricultural community. In addition, commercial field results by farmers utilizing the newest fertilizer products and techniques are collected and published in PPI publications, thus encouraging others to use them.

Mr. Tinsman

The United States is blessed with the weather and soil to be a competitive and reliable provider of vital food to the non-self-sufficient countries. But this can only be accomplished by helping the farmers reach MEY. The total fertilizer industry is indebted to PPI for its past efforts and so it will be in the future.

The future of the domestic fertilizer industry rests with the degree of PPI's and others' research efforts, and with the farmer's success. ■

Mr. Tinsman is co-owner of Twin-State Engineering & Chemical Company, Davenport, Iowa.

The Role of PPI as It Relates to the Teacher

By Darrell A. Miller

"ONE PICTURE is worth a thousand words"—we have heard this old Chinese proverb so many times, but it is so very true. One could insert Potash & Phosphate Institute (PPI) into this proverb and it would still be very true. Over the years PPI and the agronomic teacher/researcher have been close friends. In fact, the logo on the front of *Better Crops* and all of their instructional material carries the wording 'research and education' together with PPI, which has been their theme over the years. PPI has supported both research and the dissemination of its findings. The teachers are very fortunate to have an institute which provides educational material of extremely high quality in content, workmanship, accuracy, and timeliness of material to name a few. PPI is truly a friend of the teacher.

Visual Aids

Teachers must help students fix a concept in their minds so they can recall it. The visual aids prepared by and provided by PPI have the quality to gain students' attention plus arouse interest. Agronomy teachers have taken advantage of this for many years by using visual aids to complement and reinforce their thoughts and words.

Teachers Role

It has been said that the teacher who fears he might be replaced by some teaching machine or device deserves to be replaced. It's the role of an excellent teacher to use all devices to maintain interest, generate interest and insure that a student retains as much as possible. I do not see the teacher disappearing from the academic scene.

Visiting Lecturers

How many times have you wanted to have a knowledgeable individual visit class to present a new concept or summarize a general area of research in a very efficient manner? Many agriculturists have taken advantage of PPI's visiting lecturers program as it relates to fertility and general production agriculture.

Scholarship

PPI has always promoted excellence. Over the years PPI has promoted and funded excellence in research and now promotes and funds a graduate student fellowship program. The graduate student is directly involved in research so it was very appropriate for PPI to develop and fund a graduate student fellowship that is directly related to research and the training or teaching of individuals. The fellowship program has enriched our courses by giving more graduate students the opportunity to conduct research to bring to our classes and bring new blood into the teaching profession.

Dr. Miller

Thanks To PPI

Many agronomy courses have been enriched via PPI, their visual aids, teaching aids, visiting lecturers and fellowship program. The Agronomy, crops and soils, teachers as well as Horticulture, Vo-Ag Instructors, Extension, and International personnel owe a big **Thank You** to PPI for their past assistance and future support in teaching and educating our students. ■

Dr. Miller is Professor of Plant Breeding and Genetics, University of Illinois.

PPI as the Fourth Dimension: University Administrator's Viewpoint

By S.E. Younts

LAND-GRANT UNIVERSITIES and colleges in the United States evolved through a series of federal acts designed to make educational resources of such institutions available to the population at large. Although the focus of these universities and colleges is as comprehensive as the many disciplines found on the campuses, the primary thrust began around agriculture and continues to be true today.

The first legislative mandate called for the **teaching** of principles to increase agricultural production. In a few short years, it was discovered that information pools were shallow with class notes thin and dog-eared, and the second legislative mandate, **research**, was issued. New facts started coming, but an educational idea designed to reach the masses was short of the mark. The clever notion to extend agricultural education beyond the campus gate was fashioned into the third mandate, **extension**.

What has occurred in agricultural production in the United States is a great testimonial to the educational programs of instruction, research and extension of land-grant institutions. The story is unmatched anywhere else in the world, and our nation's supremacy in food production traces its origin to the land-grant movement.

But, there is more to the story of an efficient agriculture. There is the **"fourth dimension,"** one which did not come from legislative action but rather from agricultural industry itself. Born out of the realization that industry should share the responsibility for agricultural education and research along with the land-grant universities, the potash industry later to be joined with the phosphate industry, created what is known today as the Potash & Phosphate Institute (PPI). This organization has played and continues to play a unique and important role in helping farmers produce high profitable yields.

What has made this "fourth dimension" so effective and durable for a half century is quite simple. It has been a matter of practical, consistent programs of education and research shaped by a staff of talented, experienced scientists and editors who can work effectively with both university and industry personnel. PPI has placed research grants judiciously with university researchers who are constantly seeking new ways to increase yields, and PPI scientists have always been successful entrepreneurs of high-yield ideas as they move among educators and industry groups from place to place.

Dr. Younts

No central theme describes the PPI program, but if one were to be identified, it would be **"raising the level of thinking about what can be accomplished through better research techniques and improved methods and information transfer."** Certainly, land-grant institutions through their three programs of **instruction, research** and **extension** are obligated to allocate substantial resources to high-yield agriculture. They will do it, and the **"fourth dimension"** embodied in the Potash & Phosphate Institute will surely make all of us reaching for maximum economic yields more effective in our efforts. ■

Dr. Younts is Vice President for Services (academic public service and extension), University of Georgia, Athens, Georgia.

What the Potash & Phosphate Institute Has Meant to the Cooperative Extension Service

By W.J. Moline

ON THIS 50TH ANNIVERSARY, let me offer to the Potash & Phosphate Institute my heartfelt congratulations and commendation for a job well done. The Potash & Phosphate Institute staff members have been colleagues who have worked closely with their land-grant institution extension folks to bring productive and profitable technologies to agriculture. With the state of economic affairs as it is today because of financial stresses, our collective work in technology transfer is vital to the survival of agriculture and agribusiness.

Several state specialists have shared with me what their relationship has meant to their Cooperative Extension Service programs, and I'd like to share some of their thoughts. My personal experience has been first as a State Specialist, then as a Department Head, and finally as a Director.

The strong professional image by the Potash & Phosphate Institute personnel has made working together very productive. The strong professional image of the Potash & Phosphate Institute personnel is one that is earned by long years of hard work.

There are some who believe that the Potash & Phosphate Institute as an institution has served as a stablizing force in national and state workshops and seminars and has contributed to a strong basis for technology and philosophy.

Extension workers can use all the help they can get in delivering first class educational programs. Grants from FAR to state and area specialists have advanced the degree of technology development. Many of the research and development programs have been directly translated into active educational programs.

The concept of maximum economic yields serves as a working guide in the national efforts of many extension programs dealing with agricultural productivity. The concept has been motivating to producers, county agents, extension specialists, and researchers. It is my speculation that if this concept of profitability is returned to the educational programs in agriculture, our agribusiness will survive this period of low farm incomes. In Arkansas we have turned our extension efforts to working on research verification of profits in cotton, rice, soybeans, wheat and corn. The concept, encouraged by PPI, is valuable and exciting when we look at the results of five years of effort.

The challenge ahead of us in agriculture is enormous. Some faces in the traditional agricultural education and development will likely change. I know of no other support group that befriends the Cooperative Extension Service more than the Potash & Phosphate Institute, nor do I know of a stronger coworker relationship than between the Potash & Phosphate Institute and the Cooperative Extension Service personnel. This comes from clearly identifying objectives and working without regard to credit. I believe the Potash & Phosphate Institute has done well, and I salute you in this 50th year for a job well done. ■

Dr. Moline

Dr. Moline is Director, University of Arkansas Cooperative Extension Service.

International Viewpoint of PPI's Role

By E. Malavolta

I HAVE BEEN ASSOCIATED WITH PPI for at least half of its life. This gave me the opportunity to accompany and to evaluate the success of its mission, both in the USA and abroad. By promoting research and helping extend its results, a significant contribution has been made for world agriculture. Recently, its scope has been broadened, when the maximum economic yield concept was developed. In the medium and long range terms, production has to be obtained more through increases in productivity rather than by expansion of ever-diminishing agricultural land. A lesson to be learned by all.

The process of agricultural production is the final step in an orderly chain of events. At the beginning there are doubts – in the mind of the research worker – as well as questions raised by the farmer. Research and experimentation have to provide answers for both. These answers – an improved seed, a more suitable spacing, a better recommendation for fertilizer and lime use – have to be extended to the farmer who will accept the innovation if and when the diffusion step is convincing. Whenever the chief tools of agricultural policy are present – price and credit, sometimes subsidies – the better seed, the new cultural practice or the recommendation for lime or fertilizers application will be put to use. Yield will increase as will the profit margin. Progress will be made.

In the past 25 years or so, agricultural production has increased in Brazil, sometimes in a dramatic fashion. The country became the second largest (after the USA) world producer of soybeans, and number one in the export of orange juice. Production and productivity in these two cases (and a few others) were raised. The increase in production of food crops such as rice, beans, and corn, however, has been accomplished almost entirely due to the expansion of the cultivated land: productivity has remained low.

There is little doubt that low average yields of food crops can be traced mostly either to lack of effective transfer of technology to the farmer, or to the failure of ag policies which did not supply ways and means for the implementation of the research effort – the improved seed, the suitable spacing, the recommendation for fertilizer and lime use.

POTAFOS has been trying – with success – to remove some of the bottlenecks both in the acquisition and in the transfer of ag technology.

But, what is POTAFOS?

Dr. Malavolta

POTAFOS (*pota*sh + *phos*phate, in Portuguese *fos*fato) is short for "Associação Brasileira para Pesquisa da Potassa e do Fosfato" (Brazilian Association for Potash and Phosphate Research). It is a non-profit organization founded and funded jointly by the Potash & Phosphate Institute (USA) and the International Potash Institute (Switzerland), PPI and IPI, respectively. Started less than 10 years ago (1977), its roots were the Brazilian Potash Institute which was supported for several years by PPI – IPI, and which made significant contributions: 60 experiments and 100 demonstration fields established every year,

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usually in collaboration with official research institutions; 4 books published (20 thousand copies) which became compulsory source of information on coffee, sugar cane, cotton and corn.

There are two main aspects in the way POTAFOS operates:
(1) the very close connection with research and teaching institutions, extension agencies, fertilizer and lime industries, farmers and agribusiness;
(2) the consideration of all inputs (not only potash and phosphate) related to achieving maximum economic yields.

A few figures summarize the results of the work done so far:
Two dozen short courses on Soil Fertility and Fertilizers have been offered all over Brazil for a total of almost 2,000 participants (university professors, extensionists, industry, leading farmers). Symposia destined to point out ways to raise productivity of rice, corn, citrus and coffee were attended by about 1,000 people. Three seminars with the same objective aimed at the sugar cane crop were held in the Northeast. Other seminars dealt with specific aspects of nutrition and fertilization of vegetables, coffee and citrus. In many instances, seminars included the collaboration of foreign scientists. POTAFOS co-sponsored the First Brazilian Symposium on Fertilizers and Liming Materials in which both technological and agricultural aspects were discussed together. Recommendations for research institutions, extension agencies, industry and policymakers are in the process of implementation. POTAFOS took also the initiative of promoting an international symposium on The Role of Potassium in Brazilian Agriculture. Fluid fertilizers (a rather new development in Brazil) was the subject of another meeting. The management of "cerrados" — an ecosystem which covers almost 2 million square kilometers — was the subject of another seminar. Altogether — courses, seminars, symposia — were attended roughly by 5,000 people.

Equally efficient is the editorial activity which is helping to fill gaps in the Brazilian scientific literature: 7 technical bulletins and 6 books were published, many of them already in more than one edition. Nearly 100,000 copies were printed and distributed. A periodical, *Informacoes Agronomicas* (Agricultural Information) is the Brazilian counterpart of *Better Crops.* It is issued every three months: 9,000 copies are distributed within Brazil and abroad. Direct information is thereby made available to all interested parties, from farmers to research workers.

Last, but not least, POTAFOS has financially supported yearly one dozen research projects, many of them dealing with the maximum economic yield concept. Help has also been given to experimental work leading to dissertations and theses for the Master and Ph.D. degree in several universities.

For all these contributions POTAFOS has become a respected name within Brazil and in other regions. It sets an example for the contribution it has made — and will make — for the development of the primary sector of the Brazilian economy. ■

Research...The Future...and PPI

By William K. Griffith and David W. Dibb

MAXIMUM YIELD RESEARCH efforts, underway for only five years...a very short time by agricultural research standards...have had phenomenal success. They have opened doors for crop production levels regarded by many as impossible or impractical a few years ago. The table shows some of the top yields attained by North American scientists, and the number of separate research studies where these yields were achieved.

Table 1. High yields have been attained in numerous maximum yield research studies.

Crop and Yield Range (bu/A)		Times Attained
Corn, Grain	250-338 bu	20
Soybeans	75-118 bu	16
Wheat (West)	130-200 bu	5
Wheat (East)	100-140 bu	13
Wheat (Great Plains)	70-100 bu	9

Results represent numerous world, national, state, and province research yield records. The achievements attest to the positive, precise and dedicated attention most maximum yield researchers have given to the concept in their effort to attain stated yield goals.

An added dividend from the maximum yield program has been its role in helping to reawaken an interest in progressive production-agriculture research. One veteran agronomist from VPI, Dr. Daniel L. Hallock has stated: "I think maximum yield research will be one of the most productive research programs in the land-grant college movement." A continuation of this development will be essential to help establish and maintain profitable farming enterprises in the future.

Maximum yield research has been conducted on just a few soil types, under a limited number of environmental conditions, and by a relatively small number of researchers. Recently, international scientists have begun maximum yield studies. Enthusiasm for the maximum yield concept has been high wherever the program has been introduced.

Successful Maximum Yield Research Today

Successful maximum yield research has been the result of researchers integrating optimum levels of production inputs, and then following this with precision management throughout the growing season. Initial success achieved in these studies has, for the most part, not been the result of some new technology breakthrough which developed in any one of the production disciplines. High yields have been achieved by dedicated researchers who have taken the current knowledge base which has been developed through the years by soil scientists, plant scientists, plant breeders, climatologists, weed scientists, entomologists, physiologists, pathologists, engineers, etc. and put this technology to work in a high yield production system.

It is obvious that as crop production systems intensify, it will become more and more difficult for an individual scientist, working independently, in his own area of expertise, to achieve research production levels that will be meaningful to farmers of the future. Production inputs are interdependent, and a team of scientists working together as a multidisciplinary group provides a broader expertise essential for successful maximum yield studies. Several maximum yield research projects are now being conducted by the multidisciplinary approach.

Successful Maximum Yield Research Tomorrow

Today's 300 bushel corn, 100 bushel soybean, and 125 to 200 bushel wheat yields, in maximum yield research will be tomorrow's average yield for the progressive farmer.

Dr. Dibb and Dr. Griffith are staff members of the Potash & Phosphate Institute (PPI).

What will be some of the factors the multidisciplinary research teams of tomorrow must study to achieve yields that will satisfy the necessities of future generations?

Challenges Today

The first five years of the maximum yield effort give us some clues of current research needs.

Multiple nutrient application research: To obtain greater efficiency of each increment used and to provide for greater availability throughout the growing season.

Conservation tillage systems under high-yield management: Our greatest resource is soil. High-yield systems provide faster ground cover and more plant residue than average yields. These advantages must be combined with the study and development of conservation tillage equipment and practices for maximum yield research systems.

Planting pattern research: Maximum yield studies in wheat, corn, and soybeans have shown advantages to closer row spacing and/or more attention to equidistant spacing within the rows. There is a need to have close coordination in the development of planting and harvesting equipment to utilize this agronomic advantage. A current major limitation in the amount of research conducted on planting pattern is equipment availability.

Tramline concept research: The concept of tramlines to assure more uniform distribution of fertilizer and chemicals, to reduce crop damage, to allow for multiple applications, and to reduce compaction should be an integral part of maximum yield research and development.

Genetic variability research: Varieties and hybrids have been the most variable parameter used in maximum yield studies. The ability to select for genetic traits capable of high yields must be refined and integrated into the maximum yield approach. The development of new hybrids and varieties should be made under high-yield management levels to a greater extent than today.

Characterization of uncontrolled growth factors: The variation in top yield from year to year is often quite large and unexplained. The development and use of modern methods for climatological data, and other uncontrolled growth factors, are needed, to help explain yield variability in any one location and between locations. A better understanding could help develop ways to ameliorate the yield-limiting effects of uncontrolled factors.

Use and conservation of moisture: Water use and availability has been a major limiting factor in many maximum yield research tests. Water could ultimately become the most limiting resource. Irrigation management, moisture use patterns during the growth cycle, water conservation systems, rooting depth, and other moisture relationships need further study and coordination with maximum yield efforts.

Nitrogen fixation research: Some maximum yield research studies suggest that for top yield production the symbiotic nitrogen fixation process may not be capable of the highest yields without nitrogen supplementation. Further research is needed to test this observation.

Future Challenges

Biotechnology is the buzzword of the '80's. It includes such areas as molecular genetics, genetic engineering, gene splicing, cloning, recombinant DNA, etc. Some have suggested that this new area will have at least as great an impact on productivity of a crop, such as corn, as did the introduction of hybrids about 50 years ago. That is a tall order and a challenging statement. Let's look at the record and do a little projecting.

In the early 1930's, as hybrid corn was just being introduced, the average U.S. yield was about 25 bu/A. Fifty years later, the average U.S. corn yield had increased by over 300% (113 bu/A in 1982). If genetic engineering (biotechnology) can **equal** that percentage increase over the next 50 years, by the time the Potash & Phosphate Institute celebrates its 100th Anniversary (2035 AD), the U.S. average corn yield should be approaching 500 bu/A. Is that too farfetched? Some physiologists have estimated

(Continued on next page)

that today's best hybrids have yield potential in excess of 500 bu/A.

Even if we look at duplicating the absolute rather than the relative increase, the average yield in 50 years would have to be 200 bu/A. Is that more credible? Dr. Roy Flannery at Rutgers University already has a research average of 307 bu/A over a 5-year period. Certainly in 1932 an average U.S. corn yield of 113 bu/A must have seemed at least equally challenging.

Of course, this yield increase of the past 50 years has not been due solely to genetic improvement. Various estimates have suggested that somewhere between one-third and one-half of this increase is due to hybrid introduction and later genetic improvements. The rest of the package was supplied by other disciplines: soil fertility specialists improved knowledge of increased nutrient needs and timing; pathologists, entomologists, chemists and weed control specialists provided crop protection innovations; agricultural engineers provided equipment and other ag industries supplied inputs as needed allowing for more timely production operations. Many other key contributions could be named, all illustrating that in a real sense it has been an interdisciplinary effort.

If through genetic engineering we are to just double average corn yields in the next several years, what are some of the research challenges that a multidisciplinary team of agronomists and plant physiologists will face?

Light utilization and photosynthate production

Light could become limiting to some extent. Recent work by Dr. L.F. Welch at the University of Illinois has shown that supplementary light increased field corn yields almost 100 bu/A. Innovations might include improvement of light absorption by plants, photosynthetic efficiency of currently absorbed light and restructuring of plants to allow more photosynthetic efficiency for a longer period from the lower leaves in the canopy. Something as futuristic as collection and beaming of the photosynthetically most effective light spectrum into the corn fields by orbiting satellites may be a possibility for increasing photosynthate production.

Photosynthate transport

If the extra photosynthate can be produced for a doubling of yield, the transport of this increased amount of photosynthate from production source to yield sink needs to be improved. Corn plants' photosynthetic rates are often slowed by a feedback inhibition mechanism due to accumulation at the point of production.

Dr. Charles Tsai and colleagues at Purdue University are currently evaluating an assay procedure utilizing levels of photosynthetic and storage enzymes to characterize those hybrids which respond to improved management. This could have implications for future yield gains. Perhaps engineering of a corn plant with more than one active primary yield sink to facilitate more rapid transport is a logical next step.

Nutrient requirements

Rate of photosynthate transport in plants has been associated with various essential nutrients. Are currently held "critical levels" of nutrient concentrations in the plant adequate to support the increased levels of photosynthate production and transport required for a doubling of yield? In any event, just maintaining levels of nutrients in the grain, retaining nutritional value of the product, represents a substantial increase in nutrient requirement. Where do these nutrients come from? How do we get them into the plant on a timely basis without limiting yield? Attempts at foliar feeding have been made, but absorption has been slow and results erratic. Perhaps the development of a type of crop oil concentrate which binds the nutrients and penetrates the leaf, much like that now used to enhance herbicide activity, is in the future of plant nutrition.

Recent field physiology work on nitrogen form and its effect on physiological processes and yield potential may give nitrogen stabilization and management efforts a more prominent role in the future.

Nutrient uptake – the roots

The traditional way of getting nutrients into the plant is through the root system. Dr. Stan Barber at Purdue University, and others, have done pioneering work in starting to characterize this aspect of production. This is very difficult work. How much do we really know about the changes in the plant's root system as yields are doubled or tripled? What happens to root volume. . .the amount of soil explored. . .or the rate of uptake per unit of root area?

The whole subsurface area, the rhizosphere, which is teeming with biological life needs to be characterized and better managed to produce higher yields. Perhaps genetic engineering techniques will develop root systems that can overcome currently viewed soil physical and chemical restraints to adequate root development.

Most of today's yield increases have resulted from observations and measurements of the aboveground portion of the plant. Perhaps the rhizosphere holds similar keys.

Plant growth regulators

As yield mechanisms and timing of the plant's yield decisions are better defined through recombinant DNA and yield splicing techniques, the probability increases that plant growth regulators can be an even more significant component of higher yield systems. We can probably expect them to be more prominent in the future.

Interactions

These are just a few of the areas that come to mind as we consider the challenges of doubling or tripling current average and research yields. Certainly these components cannot be addressed in isolation. Dr. George W. Cooke, recently retired Chief Scientific Officer of Britain's Agricultural Research Council, has stated: "In a highly developed agriculture, large increases in yield potential will mostly come from interaction effects."

The maximum yield research approach is a multidisciplinary approach that will allow for the evaluation of innovation in these various disciplines in a production system managed to enhance positive yield interactions. As these positive interactions are identified and characterized, they can then be managed for even higher yields in the future.

Cooperation for Future Progress – A Summary

The maximum yield research approach is a look into future research. It will require bringing more of what is termed today as "basic" research into the laboratory of the traditional "production" research arena.

Advances in research areas that are now becoming more prominent such as biotechnology, genetic engineering, molecular genetics, plant growth regulators, etc. will have to be integrated into a field production "system" by a multidisciplinary team. Responses, interactions and limitations will have to be accurately and precisely characterized. Any new yield potential developed by sophisticated research will have to be supplied with appropriate nutrients and other inputs through a truly multidisciplinary effort so that the potential can be fully expressed.

Research in the future presents many challenges as we move to substantially increase yields, and do it on a profitable basis. The Potash & Phosphate Institute (PPI) and the Foundation for Agronomic Research (FAR) along with the member and contributing companies who provide the resources, are making a renewed commitment to provide encouragement, stimulation and support which will help move agricultural research and production to the heights which will be essential to sustain a profitable agriculture capable of supplying the food needs of future generations. Cooperation with researchers throughout the world has been excellent. Vision, dedication, and hard work by scientists in the field have made advancement possible. As evidenced by the past 50 years, cooperation in the future can bring even greater accomplishments. ■

Potassium in Agriculture An International Symposium

POTASSIUM IN AGRICULTURE, An International Symposium July 7-10 in Atlanta, Georgia, marks another important milestone in the history of the Potash & Phosphate Institute (PPI). The Symposium occurs as part of the 50th anniversary celebration of the founding of the Institute.

In cooperation with others, PPI is proud to sponsor this International Symposium which updates the science of potassium in modern agriculture for a broad, worldwide audience. More than 50 authorities from around the world are participating, and each speaker has authored a chapter for a new book published by the American Society of Agronomy (ASA).

Sponsors

Potash & Phosphate Institute (PPI)

American Society of Agronomy (ASA)

Soil Science Society of America (SSSA)

Crop Science Society of America (CSSA)

NFDC National Fertilizer Development Center (NFDC-TVA)

IFDC International Fertilizer Development Center (IFDC)

Foundation for Agronomic Research (FAR)

Following is a listing of the five major section titles from the book, titled "Potassium in Agriculture":

Section I.	**Potassium Reserves, Mining and Refining, Technology, Marketing, and Use**
Section II.	**Potassium in Soils**
Section III.	**Potassium in Plants**
Section IV.	**Potassium in Humans and Other Animals**
Section V.	**Potassium Nutrition for Maximum Economic Yield and Crop Production**