SCIENCE

PEOPLE

STAKEHOLDERS

Making a Difference

2018

PROGRAM REPORT

IPNI

Available online: http://ipni.info/PROGREPORT-2018

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Arab Potash Company
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The Fertilizer Institute (TFI)
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IPNI MISSION:

The mission of IPNI is to develop and promote scientific information about the responsible management of plant nutrition for the benefit of the human family.

IPNI is a global organization with initiatives addressing the world's growing need for food, fuel, fiber and feed. There is widespread concern for issues such as climate change and relationship of crop production to the environment and ecosystems, and IPNI Programs are achieving positive results. Best management practices (BMPs) for nutrient stewardship encourage the concept of applying the right product (source), at the right rate, at the right time, and in the right place.

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Dr. Terry Roberts, IPNI President, speaking at Fertilizer Association of India, 2017

MAKING A DIFFERENCE

When IPNI was first established in 2007, environmental challenges associated with fertilizer use were the primary issues of concern for society and the fertilizer industry. We spent a lot of time and energy debunking false information and alleviating public concerns about nutrient use. Soon after our launch the global food crisis started and by 2008 fertilizers were being viewed in a new light ... as a solution to the problem, rather than a problem. It was under that atmosphere that IPNI scientists introduced the idea of 4Rs; that applying the right nutrient source, at the right rate, right time, and in the right place was the ideal way to scientifically address the need to produce more food and feed while protecting our environment. The foundation of 4Rs was science-based, site-specific best practices intended to accomplish stake holder goals of food security and environmental sustainability.

4Rs have and are making a difference in how nutrients are managed around the world and how regulators perceive nutrient management. What started in North America has spread to a global movement that has taken on a life of its own. 4Rs are being adopted in Australia, China, India, Pakistan, South East Asia, the Middle East, Sub-Saharan Africa, Russia, North and South America. In the developing world, 4Rs provide much needed nutrient management tools to increase basic food and feed production, while in the developed world 4Rs provide an environmental tool to help ensure nutrients are being used efficiently and effectively.

One of the difference-making tools that IPNI has developed is Nutrient Expert®. This decision support software is changing how fertilizer recommendations are made in the developing world while integrating the principles of 4R Nutrient Stewardship. Nutrient Expert makes site-specific fertilizer recommendations based on target yields using locally available fertilizers, with or without soil test results. It accounts for straw management, manure use, previous crops, tillage, soil type, residual nutrients, and climatic conditions. In partnership with governments, extension services, and research organizations, Nutrient Expert is being scaled up in China, South Asia, Southeast Asia, North Africa, and Sub-Saharan Africa.

IPNI's interaction with the International Nitrogen Initiative (INI) has made a great impact on the direction and outcomes of this group of influential scientists. Their stated objectives are "to optimize nitrogen's beneficial role in sustainable food production and minimize nitrogen's negative effects on human health and the environment resulting from food and energy production." Working together with The Fertilizer Institute, we became involved with INI in 2001 at the 2nd International N Conference held in the USA and have been working with them ever since. We have been represented on their Advisory Committee for more than 10 years and assisted in the organization of each of the subsequent International N Conferences held in China (2004), Brazil (2007), India (2010), Uganda (2013), and most recently in Australia (2016). Our participation has resulted in each conference reporting on and recognizing the beneficial role of N in food production. We have collaborated with the International Fertilizer Association in review of the "Declaration" outcomes of these conferences to ensure that fertilizers are accurately portrayed, which is critical to how N is perceived by the international community including the United Nations and Organization for Economic Co-operation and Development. Our Phosphorus Program, initiated in July 2015, is beginning to assume a similar role with the emerging Sustainable Phosphorus initiatives.

Our work with Field to Market: The Alliance for Sustainable Agriculture has been instrumental in moving their Fieldprint® Calculator to consider all 4Rs, instead of just application rate, as it analyses and benchmarks a farmer's sustainability performance against regional, state and national standards. Similarly, we have played important roles integrating 4R principles into certification programs, including the Lake Erie Watershed 4R Certification Program, and the American Society of Agronomy's Certified Crop Adviser 4R Nutrient Management Specialty.

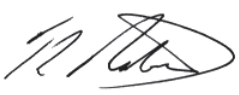
IPNI's regional programs directly impact fertilizer markets —protecting nutrient use in mature markets and increasing fertilizer use in developing markets. We accomplish this through our research and demonstration programs and educational activities. Our efforts have led to improved fertilizer recommendations from the U.S. Corn Belt to the Gangetic Plains in India to the Cerrado in Brazil. Our work has improved livelihoods for smallholder subsistence farms in sub-Saharan Africa and the large agricultural holdings in Russia.

IPNI scientists are respected by research and academic colleagues, government officials, extension workers, and NGOs, and are often sought after to serve in leadership roles, partner with in research projects, co-author papers, participate in advisory committees, to speak at meetings and a host of other activities which make a difference. Our roots in the realities of science and agriculture enable us to apply the results of research to transform crop production. We appreciate the great support of our members and their long-term vision in striving to help feed the world.

IPNI is helping the world recognize that fertilizer makes a difference, not just in global food security, but in people's livelihoods. Our new series 'Research with Impact' illustrates how fertilizer improves farmer's incomes and lives. Making a difference extends from individuals to their families, to their villages or towns … and to their countries. IPNI is proud to be part of an industry that is making a meaningful difference in people's lives.

This annual report will highlight many of the ways our programs are making a difference.

Sincerely,



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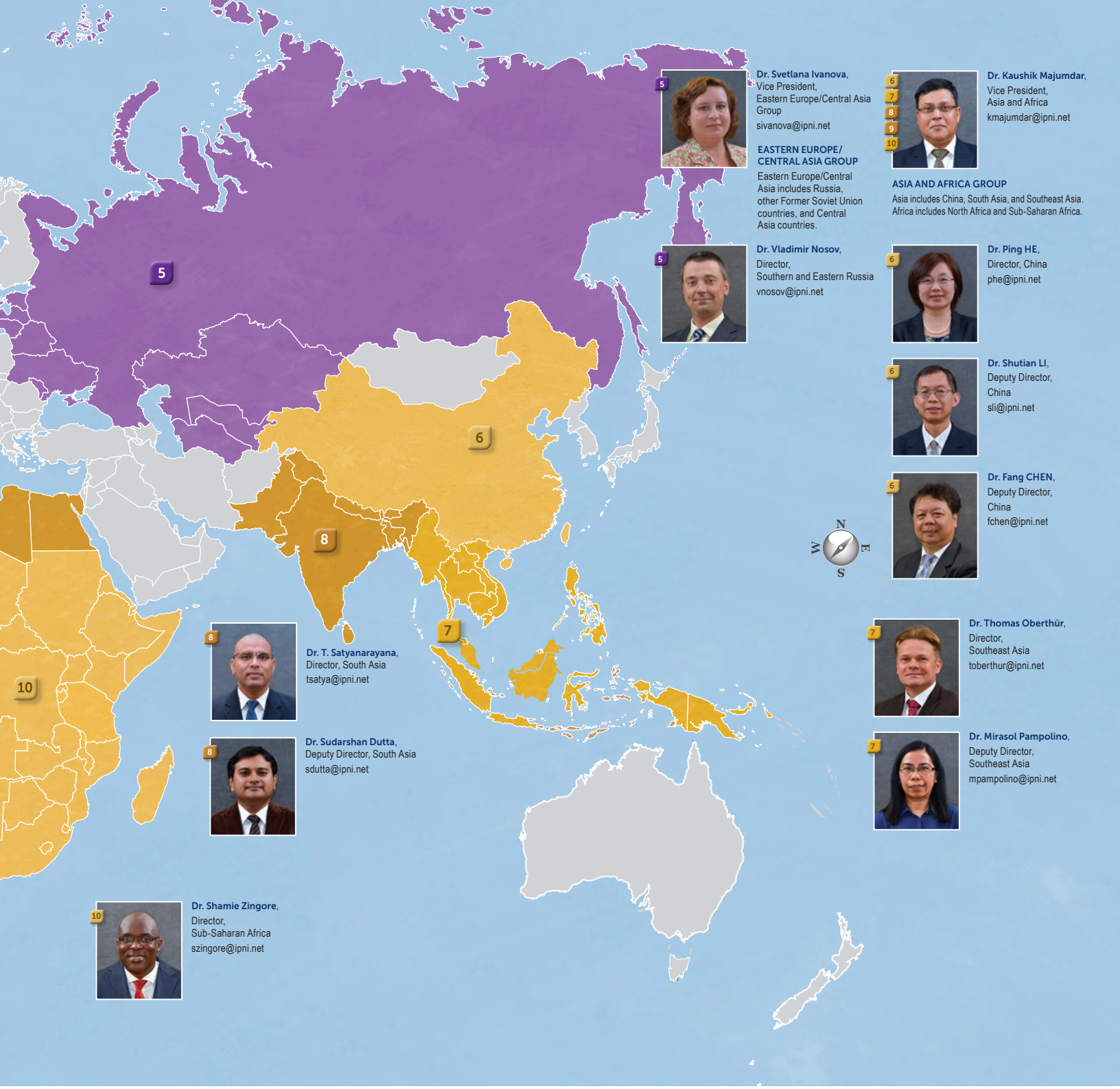

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MAKING A DIFFERENCE IN SCIENCE

BETTER SCIENCE FOR NUTRIENT STEWARDSHIP

The scientists who work for IPNI around the world share an education in the scientific disciplines of soil fertility and plant nutrition. Through their engagement of the issues associated with the responsible management of plant nutrition, they partner with and influence scientists from a wider umbrella of disciplines. This influence benefits the crop nutrition industry by ensuring that the science developed to shape policy is relevant to the reality of today's agriculture.

The IPNI Scholar Award provides recognition and support to students studying these disciplines at the graduate level. Evaluation of the hundreds of applications received each year involves most of IPNI's scientific staff. These awards build capacity for the sciences supporting nutrient stewardship.

IPNI scientists are publishing in high level scientific journals, influential on a wide range of disciplines. For example, Dr. Fang Chen and his group in China published a new mathematical model in Nature for more precisely deriving the economic optimum

from fertilizer rate trials. Dr. Tai Maaz led a group to publish a technical comment in Science Advances, correcting an erroneous estimate of air pollution impacts arising from use of nitrogen fertilizer in California. The benefits to the industry are difficult to quantify exactly, but are undoubtedly enormous.

In the pages that follow, you will see examples of IPNI scientists at work around the world. When they create collaborations of scientists in North America's Nutri-Net, assessing multiple impacts of 4R nutrient management at multiple sites, or in North Bengal, supporting field-oriented 4R decisions, they encourage partners to ask the right questions. Global projects on maize and soybean bring together scientific ideas on the advancement of ecological intensification, and take these ideas to the field. Science is engaged to implement a research framework for smallholder farms in Africa, providing evidence-based recommendations. Research groups in the Southern Cone of South America are focusing on soil health. Strong science supports the Nutrient Expert and Plantation Intelligence decision tools.

In every country around the world, and at the United Nations level, scientific evidence is being sought on which to base sound policies supporting sustainable agriculture. While IPNI does not engage directly with policymakers, the science it supports has a profound influence on the evidence base available relating to nutrient stewardship. Working in collaboration with industry associations, IPNI makes crop nutrition science based.

Sincerely,

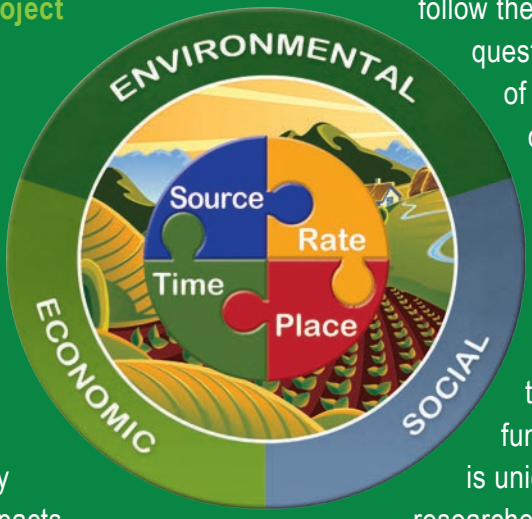
Tom Bruulsema

Tom Bruulsema, Ph.D.
Vice President, Americas & Research

Nutri-Net project team

Expanding 4R Nutrient Stewardship Science

IPNI is a key coordination member of a new **4R Research Fund Project "Nutri-Net".** This project is establishing a collaboration amongst researchers across the **Midwestern U.S. and Ontario, Canada** to collect data evaluating the efficiency of 4R practices. The coordination aspect of this project is key because it is providing an opportunity to quantify and track the impacts of 4R implementation at multiple sites. The Nutri-Net team is documenting data collection techniques so that future researchers can follow the same protocol to answer key questions regarding the impacts of nutrient management in corn-based cropping systems on water quality in the Mississippi River Basin. In the current economic climate, academic researchers are typically competing amongst their colleagues for research funding. However, this project is unique because it instead brings researchers together for collaboration on one coordinated project.



Participants of Training Workshop on Innovative Nutrient Stewardship at North Bengal Agricultural University.

To better disseminate recent research results on 4R Nutrient Stewardship, IPNI and **North Bengal** Agricultural University organized a training workshop for 50 invited scientists, extension professionals and industry agronomists. The course, entitled "Innovative Nutrient Stewardship: Concepts, Principles and Applications" was organized to present case studies that would build capacity and problem-solving skills for making field-oriented decisions. A concept note was prepared and a training website was developed. This is the first event of its kind and the first of a series of 4R-themed events planned with additional partners.

Numerous scientific articles and peer-reviewed publications were produced on 4R Nutrient Stewardship and balanced nutritional requirements of major crops like pulses, maize, and potato. For example, in commemoration of the **U.N. International Year of Pulses**, an invited article on 4R Nutrient Stewardship Guidelines for Sustainable Pulse Production was published.

IPNI supports research that explores the relationships among 4R practices, fertilizer recovery, and impacts on multiple nitrogen loss pathways.

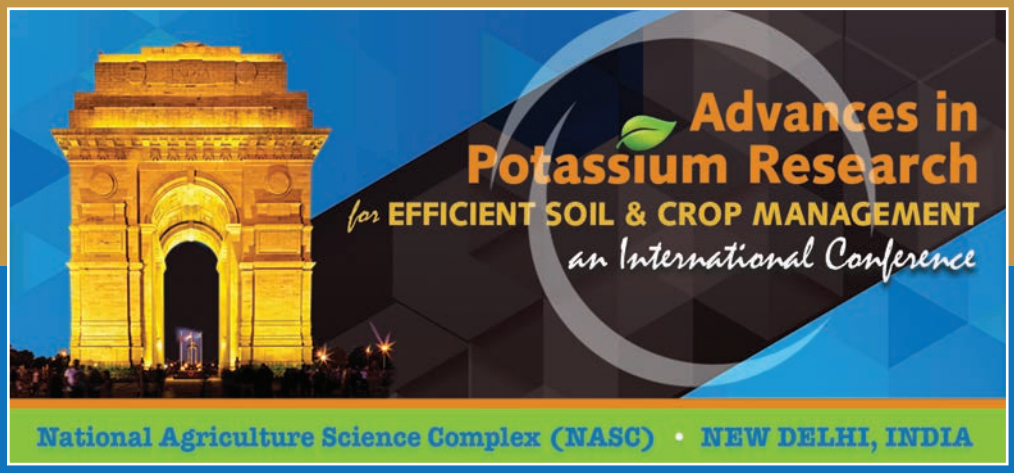
Our **Nitrogen Program** is currently focused on improving the scientific understanding of how 4R Nutrient Stewardship reduces nitrogen losses from cropping systems.

Dr. Scott Murrell, Potassium Program Director, and **Dr. Kaushik Majumdar,** VP Asia and Africa, at inaugural event of the National Conference on Advances in Potassium Research for Efficient Soil and Crop Management in New Delhi.

New Delhi conference participants

Innovative Concepts and Frontier Technologies

Our **Potassium Program** is leading improved approaches to assess the need for potassium fertilization. In three recent conferences dedicated to potassium science, IPNI has initiated discussions on how to accurately determine the potassium status of soils and predict how long the soil can supply adequate potassium to crops. We have also fostered discussion of new ideas for increasing the effectiveness of potassium fertilizer applications. These ideas are archived in the various **conference presentations available here.** These innovative concepts are now being organized and brought together into a book to be published later this year.



The national conference on “Advances in Potassium Research for Efficient Soil and Crop Management” was organized in **New Delhi,** with an accompanying book covering the ongoing research and educational activities related to potassium. The conference was jointly sponsored by IPNI and other leading Indian scientific organizations. The speakers were able to highlight advancements in potassium science, frontier technologies, research gaps, and extension needs to overcome inadequate potassium fertilizer use.

Ecologically Intensive Practices

Our **Global Maize** project aims to create locally appropriate, ecologically intensive practices that close yield gaps and increase nitrogen use efficiency.

For example, Global Maize has several research sites in **Virginia, USA** where concepts related to intensive maize production are being tested. Specific studies underway include how to involve model-based decision support systems for in-season nitrogen fertilizer applications, variable-rate phosphorus and potassium fertilizer management based on grid sampling of the soil, and variable-rate seeding based on field management zones.

***Dr. Steve Phillips,** Director, North America Program (second from left), visits Virginia Global Maize site with collaborators and IPNI staff.*

IPNI Global Maize Projects *(Click on the map for details)*

Pooling Resources

Our Global Maize project brings together scientists of different institutions to examine the effects of cropping systems management on maize yield, with support from the Ministry of Science and Technology of **Argentina**.

Another example is the IPNI-led research on **breaking soybean yield barriers,** which coordinates the efforts of international scientists, universities, and the Argentinean National Agricultural Technology Institute. Recent publications and webinars point to several opportunities to improve soybean yields through improved nutrient management.

Watch ***Dr. Fernando García,*** *Director, Latin America-Southern Cone Program, and his collaborator describe the IPNI project on breaking soybean yield barriers.*

Research collaborators at Argentinean Global Maize site.

TAKE IT *to the* FIELD

A lack of modern information on plant nutrition and proper fertilizer use is serious challenge in **Eastern Europe and Central Asia**. Development of science-based recommendations supporting balanced plant nutrition is a high priority and can make a signification contribution to regional agricultural production and fertilizer market development. **A recent example is an IPNI-led research project on forages conducted in Volgograd,** the key region for the milk production in North-West Russia. The on-farm research had a special focus on increasing forage yields and quality through more precise applications of nitrogen, phosphorus, and potassium fertilizer and more intensive grass cutting. Results from two seasons show that higher mineral fertilizer application rates, combined with more intensive grass cutting result in a significant increase in the yield and quality of forages, as well as improving the economics of forage and milk production. The practical outcome is the development of a fertilizer management system for very high-yielding forage production.

*Watch **Dr. Vladimir Nosov,** Director, Southern Russia Program (second from right) as he visits a rapeseed trial in the Republic of Bashkortostan.*

Five research projects have been leading the science of plant nutrient management in **Southern Russia**. Research in the Republic of Bashkortostan has shown that spring rapeseed yield and oil content are increased by implementing 4R Nutrient Stewardship. In Voglograd Oblast, a combination of fertigation and foliar fertilization improved both tomato quality and marketable yields. Wheat yields and protein content are increased by adopting late-season fertilization and foliar fertilization. Similarly, barley yields are increased by fertilizing the crop at the right time and including sulfur in the fertilizer blend.

Fertilizer left on the soil surface can be lost during runoff.

Best Science for the Farmer

One of the main goals of IPNI scientists is to address the state of the art related to practical nutrient management information. Our Program publications, with articles from our own research and from key partners, summarize what is the best science and ready to deliver for crop consultants and farmers on the subject of plant nutrition. We make a difference with the science we transfer to the field. One example from **Brazil** is a recent article published on **"Phosphorus Placement for Annual Crops in the Tropics"**. In this article, readers can find key information about how to manipulate phosphorus fertilizer placement to increase agronomic and environmental efficiency. The main messages in the article were summarized in the form of ***"Take It To The Field"*** as seen below.

TAKE IT TO THE FIELD

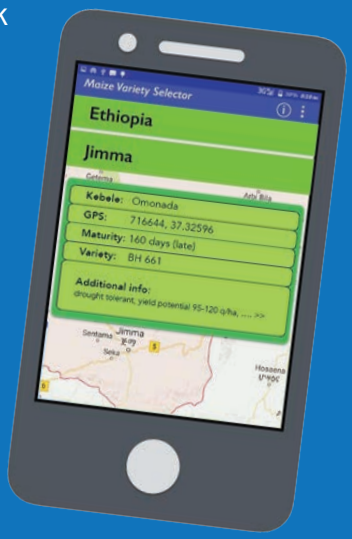
1. Farmers should promote practices that increase the soil P concentration throughout the profile and not just the surface.
2. In years with good water availability and P supply, expect little agronomic difference between broadcast or more localized P placements. Differences may only happen when the water supply is inadequate.

> *IPNI continues to lead regional initiatives to develop standardized protocols for field research, data analysis, and models for interpreting soil and crop information…*

Dr. Shamie Zingore
Director, sub-Saharan Africa Program

Satisfying the Need for Speed

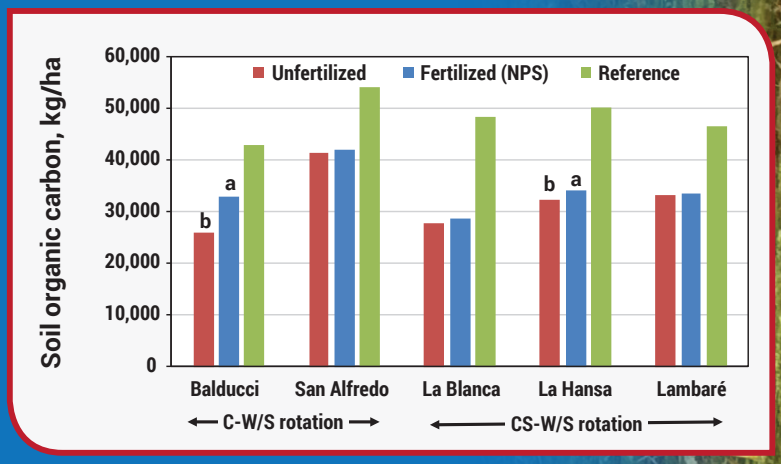
IPNI has made a major contribution in the development of innovative research methods for improved nutrient management recommendations for smallholder farming systems in **sub-Saharan Africa**. This is a priority due to the urgent need to increase crop productivity and fertilizer use to address human nutrition and food security in a region where farmers face complex challenges. IPNI continues to lead regional initiatives to develop standardized protocols for field research, data analysis, and models for interpreting soil and crop information leading to improved nutrient management recommendations. A systematic research framework that enables accurate, rapid and cost-effective development and dissemination of improved nutrient management recommendations has been developed and used by wide-ranging cooperating institutions. The framework addresses existing soil and crop data, any soil-based yield constraints, and then suggests practical options for overcoming yield barriers. By leading a network of private, NGO, and research/extension institutions, IPNI is working to achieve adoption of practices for improving nutrient management recommendations by many thousands of smallholder farmers.

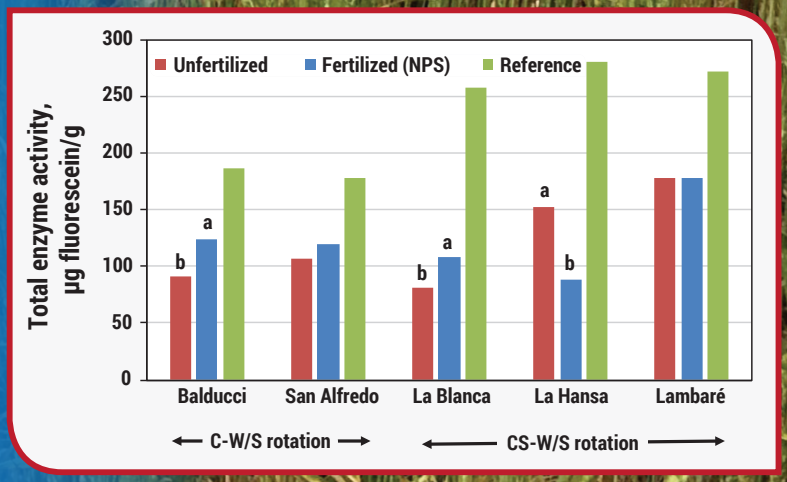


Maize Variety Selector application

Leader of Field Experiments

The **Southern Cone** Program is working together with many research groups to document the benefits of 4R Nutrient Stewardship on both agronomic success and soil health. For example, since 2000 IPNI has been leading the Nutrition Network (CREA Southern Santa Fe), an on-farm network of field experiments. Research groups from the University of Rosario have studied soil health under different fertilization treatments. In Uruguay, IPNI closely collaborates with the College of Agronomy from the Universidad de la Republica and the National Institute of Agricultural Research to identify crop potassium deficiencies and yield responses to fertilizer application.





Soil organic carbon (top), and enzymatic activity (right) for unfertilized, fertilized, and reference plots. Different letters indicate significant differences between treatments after 12 years of study ($p \leq 0.05$).

Dr. Shutian Li, Deputy Director, China Program (second from right), with local research collaborators.

Predicting Future Fertilizer Consumption

Our **China Program** has launched an extensive program to improve the accuracy of Nutrient Expert.® On-going projects focus on the use of potassium and nitrogen for sunflower, and how various sources of potassium and phosphate promote high yields and quality of apples. Numerous experiments were initiated on various vegetable crops to calibrate Nutrient Expert® software for improved fertilizer recommendations for more than 25 horticultural crops. An additional project assessed the quantity of nutrients from various organic residues that could be recycled back to crops as a guide for predicting future fertilizer consumption trends under the government zero-growth policy for fertilizers.

Nutrient Expert Training Workshop.

Strategic Recommendations

In many regions in the world, cassava is grown by farmers who traditionally do not apply fertilizer to this crop. When cassava is grown on the same area for many years without adequate fertilization, the soil becomes depleted and degraded. Where cassava is grown continuously for at least 8 years, potassium often becomes the most yield-limiting nutrient. The **IPNI Southeast Asia Program** initiated research to apply 4R concepts of nutrient management using Nutrient Expert® to predict cassava response to applied fertilizer. During the early years of research, yield response was greatest to additions of nitrogen followed by potassium, and then phosphorus. Improved fertilizer recommendations based on Nutrient Expert® result in 6 t/ha of additional cassava roots, compared with the standard government recommendation. This new data will be used to further refine the Nutrient Expert® tool for making improved fertilizer recommendations for cassava to boost farmer productivity and minimize soil degradation.

PLANTATION INTELLIGENCE

Our **Southeast Asia Program** has also developed the Plantation Intelligence (PI) tool to apply the concepts of strategic and tactical business intelligence to the palm oil industry. The process starts with acquiring data, preliminary analysis, and discussion with management to identify the most significant factors. PI then provides input to the plantation business plan by clarifying the fertilizer performance in an operation. This allows quantification of the opportunities provided by management changes of key input resources and agronomic activities. The PI tool clarifies how linked factors such as variable block productivity, cost of fertilizer, soil, and weather impact economic performance. Managers can then make rational decisions how to implement optimal fertilizer strategies.

Fertilizer recommendations based on Nutrient Expert® resulted in 6 t/ha of additional cassava roots, compared with the standard Philippine government recommendation.

Dr. Thomas Oberthür,
Director, Southeast Asia Program
with a smallholder farmer.

Dr. Hakim Boulal
(second from left), Deputy Director,
North Africa Program

Innovative Research

Research efforts of the IPNI **North Africa Program** focus on the important crops in the region. On-farm research in Morocco, Algeria and Tunisia showed that the use of Nutrient Expert® recommendations results in significant positive wheat yield responses to fertilizer applications. Improvements in yield and farm profitability resulted from use of Nutrient Expert®, compared with current farmer practice or official regional fertilizer recommendations. In some cases, potassium fertilizer had an additional benefit of reducing the severity of crown root rot in durum wheat. On-going research with olives revealed that up to a 30% increase in yield and a 20% increase in oil production is possible if fertilizer recommendations are adjusted based on leaf analysis and nutrient crop removal instead of traditional fertilization techniques.

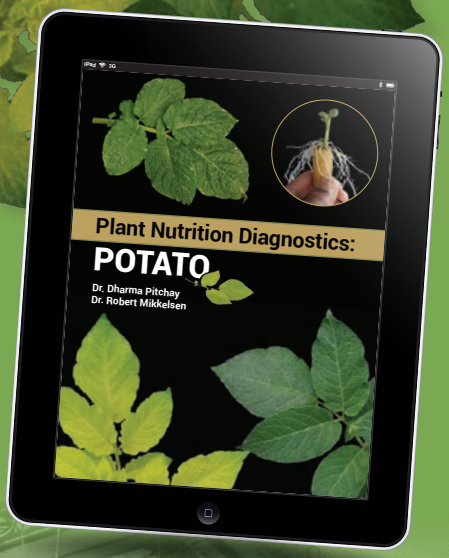
Weeds often pose a major challenge for achieving high crop yields. Added fertilizer can cause weeds to flourish and chemical control can be expensive. New IPNI research shows that the development of weed communities is closely related to soil nitrogen and phosphorus concentrations, the soil organic matter content, and sunlight transmission. A new model is being developed to achieve better weed control by modifying fertilization and crop management practices, achieving higher crop yield and requiring less herbicide application. In another project, the rice yield response to added fertilizer was found to be better predicted using a Unary Non-Structural Fertilizer Response Model, allowing more accurate estimations of the return on investment from added nutrients.

Dr. Fang Chen,
Deputy Director, China Program

Diagnostic Tools

Plant nutrient deficiency symptoms can be a powerful diagnostic tool for improving plant health. A research project was established to document the nutrient deficiency symptoms of potatoes. After the high-resolution photographs of the leaf symptoms were obtained, IPNI assembled all the images into an e-book that has now been distributed in major potato-growing areas. Translations of the English version of the book into several other languages are planned for 2018.

*Listen to **Dr. Dharma Pitchay,** coauthor of our recent e-book, describe the science behind his work.*



Dr. Robert Mikkelsen (on right), VP Communications with research and industry collaborators.

MAKING A DIFFERENCE FOR

PEOPLE

REACHING PEOPLE WHO MAKE A DIFFERENCE WITH PLANT NUTRITION SCIENCE

People adopt or influence changes to make the difference. The next few pages provide a snapshot of activities we do across the world to reach out and communicate best nutrient management practices to people.

I recently met a smallholder oil palm farmer in Ghana where my sub-Saharan Africa Program colleagues were working with oil palm plantations and their catchment smallholder farmers for implementing crop and nutrient best management practices. He told me that before IPNI scientists started interacting with him, he would only go to his farm to spread some fertilizer and harvest about 5 t/ha of fresh fruit bunches (FFB). His farm was full of weeds making it difficult to access the trees and harvest the crop. When I visited him, his farm was clean, the fertilizer application area around the oil palm trees clearly marked, he knows what, how much, when, and how to apply his fertilizer, and spends better part of the day in his farm tending the trees; the result is a 19 t/ha of FFB yield. Imagine the difference

this makes in the livelihood of a smallholder farm family or sustainability of palm oil production.

Similar stories exist across IPNI Programs. From cocoa smallholder farmers in Indonesia, to forage producers or dairy farmers in Russia, to maize farmers in Argentina, China, or Nepal, it's all about reaching people with better plant nutrition information. We can build capacity at multiple levels, making a difference on how fertilizer is managed to improve productivity and profitability so farms can contribute to the bigger picture of better food security, livelihood, and sustainability.

The vehicle of these changes has been the 4R Nutrient Stewardship Principles that IPNI and the fertilizer industry jointly developed and promoted. The science of the 4R crystallized around 2007, about the same time IPNI started its operations. I am amazed how quickly it has become the cornerstone of plant nutrient management strategies. Cereals, annuals, perennials, forests, grasslands, big farms, small farms, tropics, temperate regions, you name it, and the principles provide the framework to design a 4R strategy for sustainable nutrient management.

IPNI has developed a fertilizer decision support tool, the Nutrient Expert®, to assist farmers and their advisors implement 4R practices at their farms. Led by the Southeast Asia Program, the Nutrient Expert® tool development and dissemination now covers 18 countries and 6 crops across five IPNI Programs in Asia and Africa. The government research and extension organizations of these countries are supporting the Nutrient Expert® initiative with significant financial and human resources to reach more crops and farmers. The tool has the potential to make a difference for millions of smallholder farming families by improving their crop yield and profitability through efficient nutrient management.

IPNI has a limited number of staff managing large regional programs. Our Directors work closely with leading experts and collaborators to develop a suite of 4R practices that are tailored to crops, regions or sustainability goals. They leverage the strength of groups like the Certified Crop Advisers in North America and farmers' groups like CREA (Regional Consortium for Experimental Agriculture) in Latin America to take these 4R messages forward more efficiently. Through our leadership in the InfoAg Conference, the K conferences in Rome and New Delhi, other regional symposiums and mega field events, IPNI scientists connect with leading experts, collaborators, policymakers and sustainability organizations to underline the positive role of fertilizers for sustainable intensification of production systems around the world.

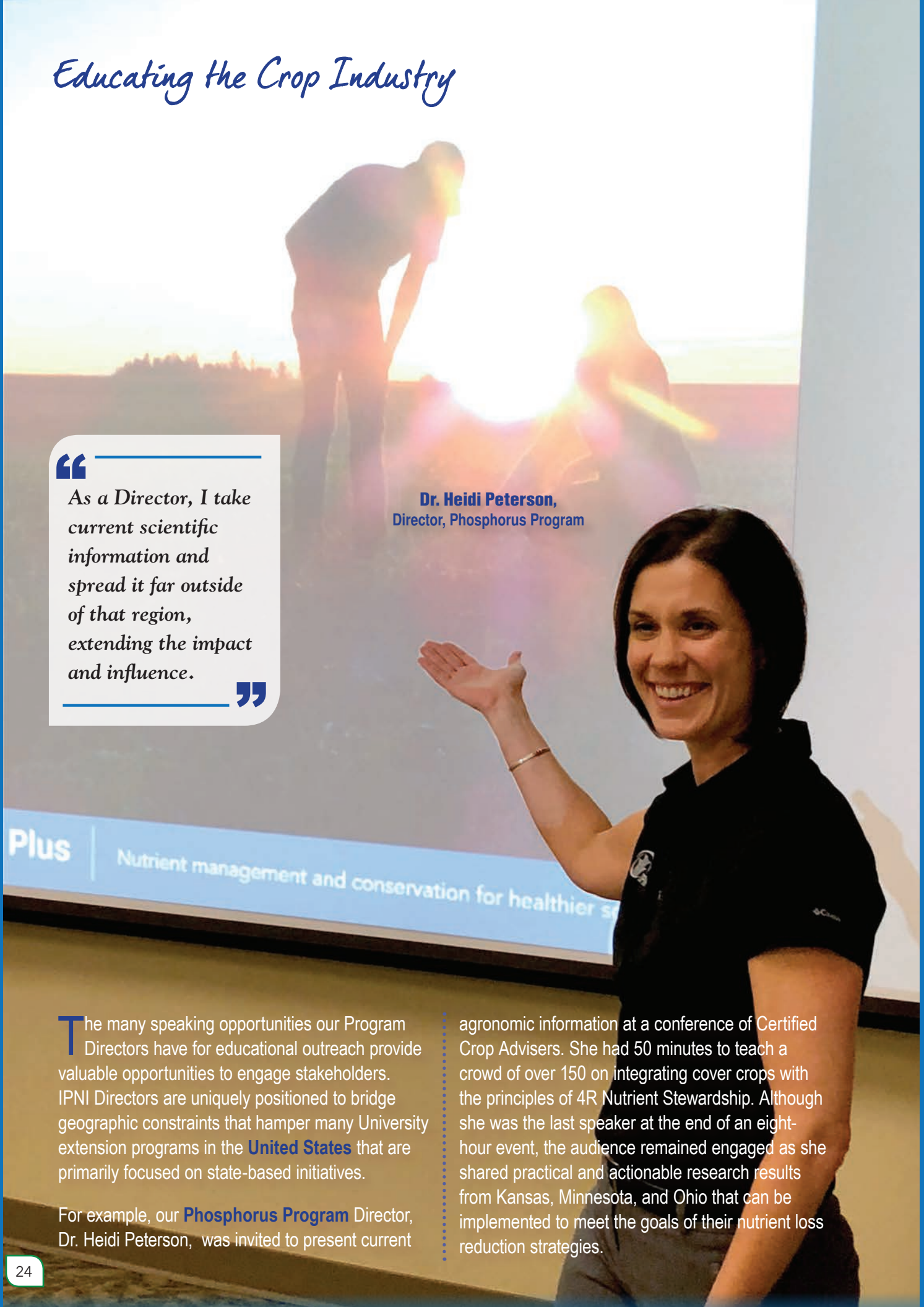
Sincerely,

Kaushik Majumdar

Kaushik Majumdar, Ph.D.
Vice President, Asia & Africa

Dr. Kaushik Majumdar
(center)

Educating the Crop Industry



> *As a Director, I take current scientific information and spread it far outside of that region, extending the impact and influence.*

Dr. Heidi Peterson,
Director, Phosphorus Program

The many speaking opportunities our Program Directors have for educational outreach provide valuable opportunities to engage stakeholders. IPNI Directors are uniquely positioned to bridge geographic constraints that hamper many University extension programs in the **United States** that are primarily focused on state-based initiatives.

For example, our **Phosphorus Program** Director, Dr. Heidi Peterson, was invited to present current agronomic information at a conference of Certified Crop Advisers. She had 50 minutes to teach a crowd of over 150 on integrating cover crops with the principles of 4R Nutrient Stewardship. Although she was the last speaker at the end of an eight-hour event, the audience remained engaged as she shared practical and actionable research results from Kansas, Minnesota, and Ohio that can be implemented to meet the goals of their nutrient loss reduction strategies.

*Listen to **Dr. Prochnow** describe a list of educational tools available to agronomists and growers in Brazil.*

> *Although we interact directly with many farmers throughout Brazil, it is even more effective to train the trainers and influence the influencers to increase our impact.*

Dr. Luís Prochnow,
Director, Brazil Program

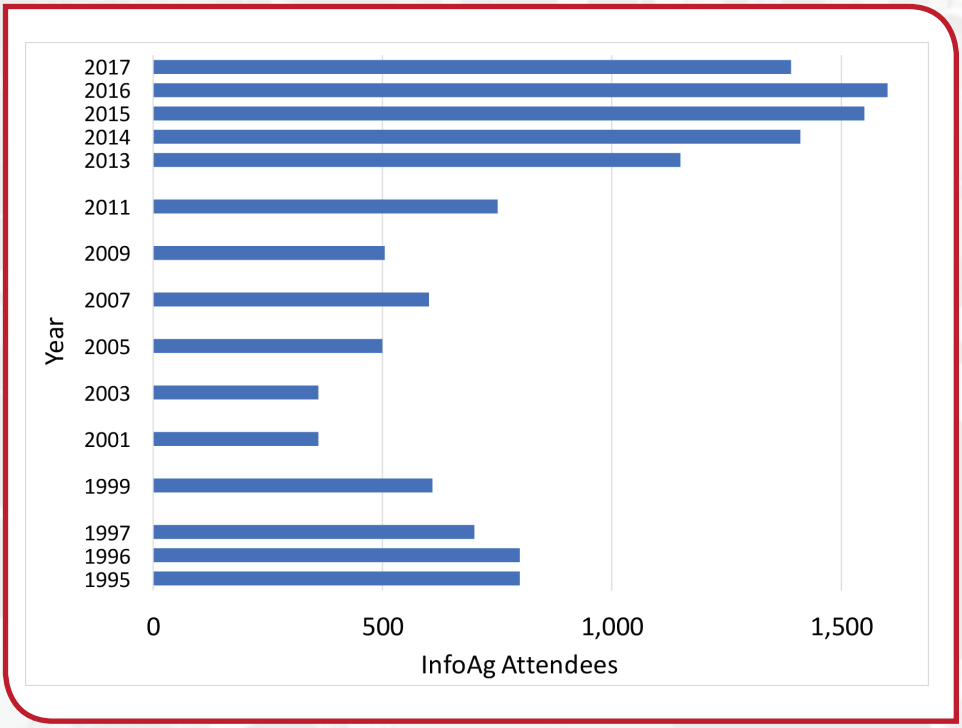
In some regions, our main target is to work with crop consultants and provide them the best possible information so they can use nutrients wisely. Through our educational activities, thousands of consultants are trained each year to better advise farmers around the country about the 4R approach to managing nutrients. To accomplish this goal in **Brazil**, our public training events are a fundamental activity, consisting of organizing appropriate forums to educate consultants who will ultimately train the millions of farmers in the country. One recent example is our "Symposium on Precision Agriculture as a Tool for Fertilizer Best Management Practices", where agronomists received the most recent information about how to best implement precision agriculture techniques in Brazil.

With Mixmate mobile blending

High Tech Leadership

The annual InfoAg Conference (http://infoag.org) serves a valuable educational purpose for crop advisers, agricultural input dealers, service providers, researchers, and farmers engaged in precision agriculture. The precision agriculture industry continues to grow and InfoAg is the premier event in **North America** for information exchange among these groups.

IPNI demonstrates leadership in this arena by developing a high-level educational program for the conference each year. The impact of InfoAg has expanded beyond North America, as evidenced by increased attendance from other countries. To respond to the growing interest in the conference, the first InfoAg International Conference will take place in 2019.



The number of attendees at the InfoAg Conference continues to grow.

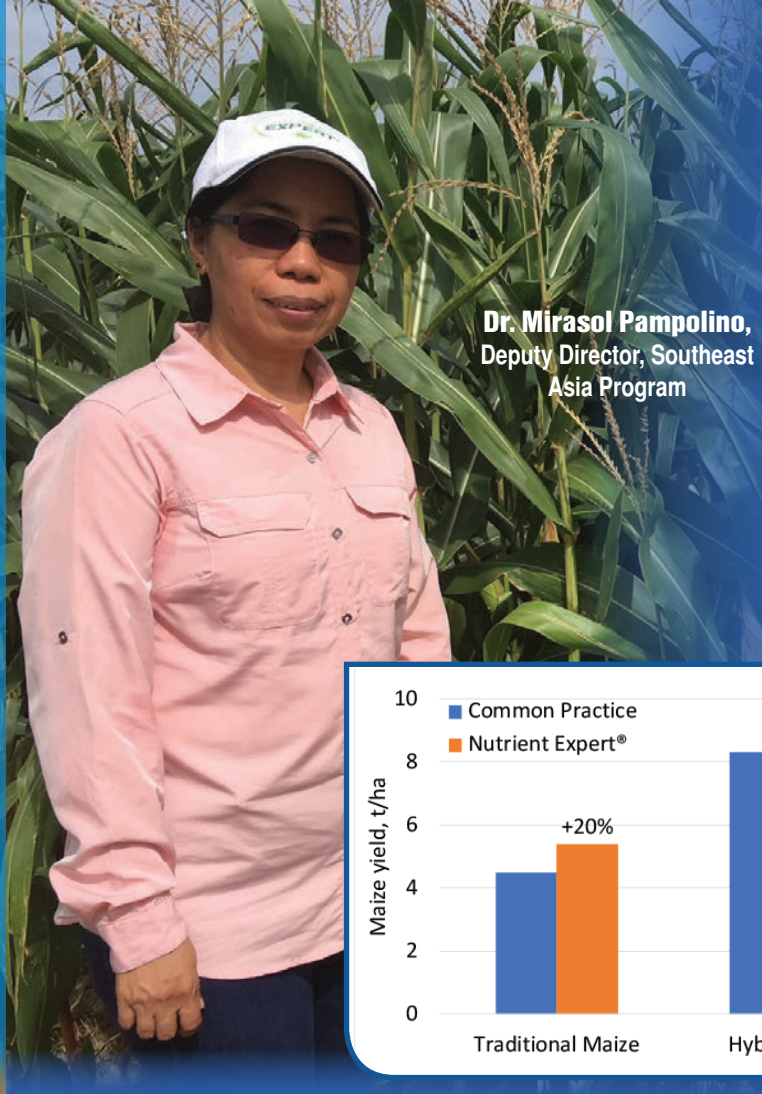
Dr. Ping He,
Director, China Program

> *National research organizations now promote Nutrient Expert® as an accepted way of making fertilizer recommendations…*

Support System for Nutrient Expert®

Our **China Program** has a 30-year history of supporting activities that promote balanced plant nutrition. Most recently, the adoption of 4R Nutrient Stewardship has been enhanced through wide-spread acceptance of the Nutrient Expert® tool for making fertilizer recommendations in situations where soil testing is not available or adequate. National research organizations now promote Nutrient Expert® as an accepted way of making fertilizer recommendations and have recently funded IPNI to expand the number of crops that can be targeted.

Opportunities for explaining 4R Nutrient Stewardship and Nutrient Expert® for wheat, maize, rice, and soybean regularly occur for training scientists, technicians, farmers, fertilizer dealers, and students. This educational outreach is further supported by a network of field demonstrations of balanced fertilization for various crops around the country. Considerable work has been devoted to publication of peer-reviewed articles, books, proceedings, Better Crops articles, brochures, and videos.



Dr. Mirasol Pampolino,
Deputy Director, Southeast Asia Program

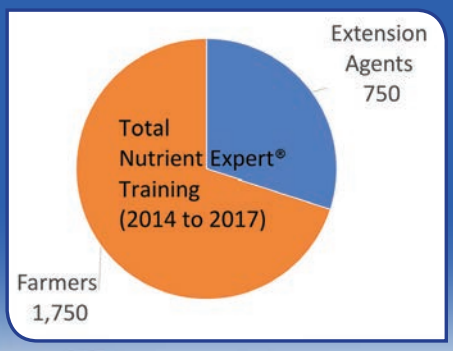
The Tool of Choice

Nutrient Expert® allows crop advisers in the **Philippines** to quickly generate a 4R-based fertilizer recommendation for a specific field and corn variety. This tool was developed and field tested with support from key government, university, and private industry partners. On average, Nutrient Expert® consistently recommended increased application of potassium for all varieties and also increased phosphorus application for hybrid maize. Average nitrogen fertilizer recommendations were largely unchanged, but management changes were recommended to more effectively apply fertilizer during the growing season. To reach more Filipino maize farmers, Nutrient Expert-Maize is now promoted by the Department of Agriculture. Private fertilizer companies and farmer groups have also started in using and promoting the tool.

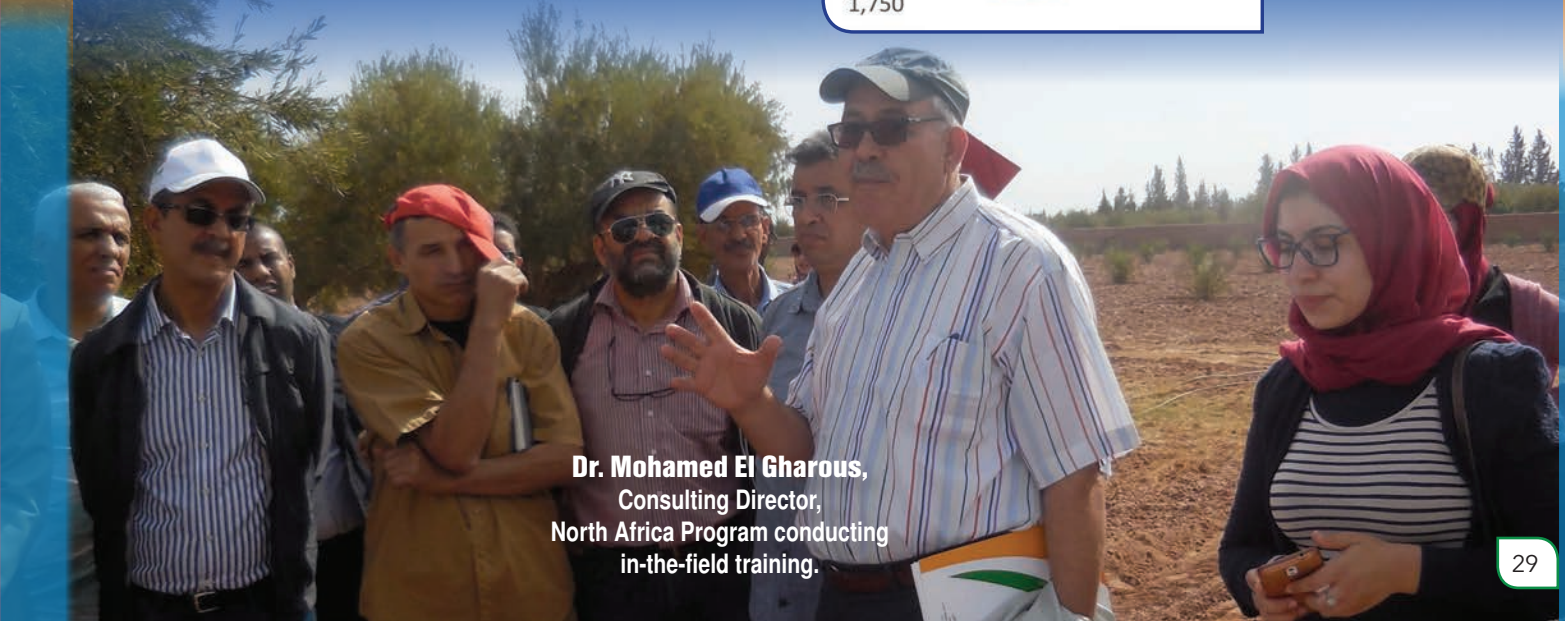
Nutrient Expert® increased maize yields in the Philippines by 12% for hybrid maize and 20% for traditional varieties.

Training and Fertilizer Recommendations

In **North Africa**, during the last five years, extension agents, scientists, and fertilizer dealers, and farmers have received training on 4R-based nutrient management and the use of Nutrient Expert®. During this past year, more than 1,800 farmers received fertilizer recommendations for wheat using Nutrient Expert®, in collaboration with the Moroccan government extension services.



Field days have trained more than 2,500 participants since 2014, of whom 70% are North African farmers and 27% are extension agents.



Dr. Mohamed El Gharous,
Consulting Director,
North Africa Program conducting in-the-field training.

Expert Collaborators

IPNI Programs attract collaborators with the greatest expertise. Each IPNI Director and Deputy Director has his or her own network of experts and leaders. Working within this web of connections, our **Potassium Program** has been able to access leading scientific experts and tap into information not otherwise possible. The result of this process has been a gathering of a diverse set of leading global potassium-focused scientists willing to work together to address the complex issues that hamper our abilities to accurately assess potassium fertilizer needs.

Group photo of global potassium-focused "Frontier" scientists.

Dr. Sudarshan Dutta,
Deputy Director, South Asia Program
(center) in discussions with Indian research collaborators and IPNI Staff.

Extraordinary Cooperators

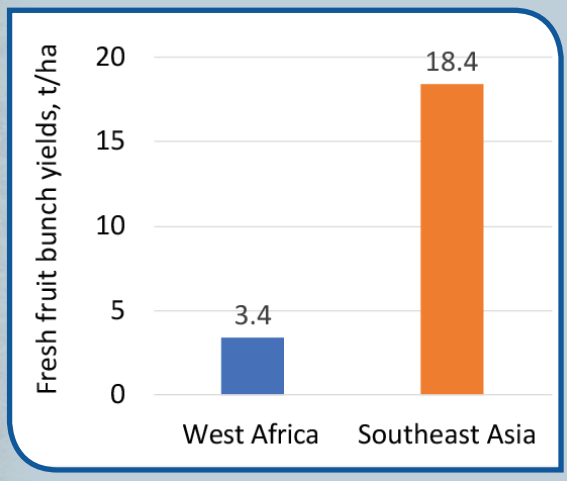
Partnership and collaboration with **South Asian** university scientists is a key leadership role that IPNI regularly performs. The many IPNI cooperators from research and education sectors feel proud to showcase their efforts in front of large audiences, including peers, industry professionals, policymakers, and extension professionals. Our cooperators are encouraged to participate in national and international conferences where they present the results of IPNI-supported research projects that we are jointly conducting. Scientists cooperating with IPNI Programs publish peer-reviewed articles and organize events using university and government resources to further advance the IPNI mission of research and education.

Dr. T. Satyanaryana,
Director, South Asia Program

Impacting the Local Farms

Watch a brief video about our oil palm best management practices project underway with our partners in Ghana.

IPNI and Solidaridad's Sustainable West Africa Palm Oil Program (SWAPP) initiated a project to identify and implement practices to increase yields for both smallholder farms and plantations in Ghana. The project successfully identified techniques to improve yields (e.g., increasing yields from 8.5 to 12.6 t/ha), and then developed educational and training activities to help local farmers. Our **sub-Saharan Africa Program** was able to demonstrate the great potential for increasing oil palm production in Ghana by adopting improved management techniques.



Yields from oil palm production in West Africa are currently very low and efforts to increase production has mainly focused on expansion into new land. Fruit bunch yields currently average about 3.4 t/ha, which is less than 20% of the yields obtained in Southeast Asia (18.4 t/ha). Poor yields in West Africa are caused by a combination of climate, poor soils, inadequate and unbalanced fertilizer use, and substandard field management.

Scouting oil palm in Ghana with plantation managers.

Excellent Management Brings High Yields for Farmers

Cocoa yields in the smallholder farms of **Sulawesi, Indonesia** are typically less than 500 kg/ha, yet attainable yields are substantially higher. To overcome this yield gap, we conducted on-farm trials between 2013 and 2016, with support from several industry and social organizations. The goal was to determine the benefits of mineral fertilizer on yield and bean quality, and its impact on farmer income from growing cocoa. All participating farmers received training on fertilizer use and tree management.

Yields were increased to above 2 t/ha with proper fertilization and management for some farmers, while other farmers had very little additional yield. High cocoa yields were almost always associated with increased fertilization. Dry climate conditions associated with the strong El Niño effect in 2015 generally reduced yields. Farmers who have excellent management can safely apply fertilizer with minimal risk of losing their investment if bean prices fall to minimum levels, even when weather conditions are poor. In general, fertilizer recommendations should be adjusted to the level of management that the farmer can achieve and the expected weather conditions, rather than making blanket recommendations.

Smallholder cocoa growers sorting harvested pods.

The 4R Message with Tailor Made Plans

Our **Nitrogen Program** is connecting 4R Nutrient Stewardship with improvements in economical, agronomic, and environmental outcomes. IPNI has worked with leading experts to develop suites of 4R management practices that are tailored to specific crops and regions. These suites of 4R management are designed to help growers and crop consultants attain specific sustainability goals. IPNI educational programs on nitrogen management empower farmers to make constructive changes in their fertilization practices. Advancing science-based fertilizer recommendations also provides opportunities to engage with policymakers and sustainability associations searching for unbiased information for improving regulations.


INTERNATIONAL PLANT NUTRITION INSTITUTE

ISSUE REVIEW

Ref #16057

Suites of 4R Nitrogen Management Practices for Sustainable Crop Production and Environmental Protection

By Cliff Snyder

September 2016

Interactions with farmers in Argentina, Bolivia, and Paraguay are one of the main activities of the **Southern Cone Program.** For example, in Argentina and Bolivia, IPNI partners with the farmer-led group CREA (Regional Consortium for Experimental Agriculture) to coordinate on-farm experimentation, promote farming sustainability, and provide nutrient management information through various workshops and conferences. Similar activities are carried out with no-till farmer´s associations of Argentina and Paraguay (AAPRESID at Argentina, and FEPASIDIAS at Paraguay). Through these and other educational activities, the message of 4R Nutrient Stewardship has been widely disseminated and farmers are increasingly empowered to improve their productivity and profitability by adopting these management changes. Educational outreach to university students in both Argentina and Paraguay provides opportunity to train future agronomists about the importance of nutrient management.

Field day with farmer-led group CREA (Regional Consortium for Experimental Agriculture) in Argentina.

Dr. Svetlana Ivanova, VP Eastern Europe & Central Asia and **Dr. Vladimir Nosov,** Director, Southern Russia working with field day attendees.

Field Days with Banner Results

IPNI Directors regularly participate in agronomic training and field days aimed at educating farmers on improved nutrient management techniques. Industry-sponsored training in **Krasnodar, Russia** and sugar beet field days in Balti, Mondova provided opportunities to expose 4R nutrient management to farmers and scientists. These regional events are excellent opportunities to explain the benefits from adopting 4R nutrient management and answer their specific questions on crop nutrition.

The results of IPNI research projects in **Eastern Europe/Central Asia** are rapidly disseminated to groups who may benefit. For example, upon the completion of a project on forage production in Volgograd, communication outreach to the dairy industry became a priority. Dr. Svetlana Ivanova participated in Agrofarm 2017 (Russia's leading exhibition for animal husbandry), an important meeting supported by the Russian Ministry of Agriculture. Dr. Ivanova was later invited to speak on the topic: "Best silage in Russia – 2017", which attracted representatives of the largest dairy farm in Russia. She delivered a presentation on intensification of forage production in Volgograd, which highlighted the results of IPNI research. Dr. Ivanova presented her research results for Miratorg' staff of 80 agronomists and crop managers in Central Russia. Miratorg is the largest producer of poultry, pork and beef in Russia.

MAKING A DIFFERENCE FOR

STAKE-HOLDERS

SIGNIFICANT PROGRESS ACHIEVED THROUGH COOPERATION WITH STAKEHOLDERS

Substantial improvements of crop production systems are necessary to meet the food demand of a growing world population. By implementing 4R Nutrient Stewardship into practice, IPNI contributes to the development and dissemination of science-based knowledge on crop production to meet the necessary improvements in agricultural productivity and sustainability. Nowadays, sustainable agriculture requires more efficient utilization of the main resources involved in crop production – arable soils, fertilizers, energy, and water in order to reduce the environmental impact of agriculture, as well as achieving more effective application of research output.

Modern crop production is becoming more competitive and

complex, combined with provision of other environmental goods and services, and fostering human and animal health and safety. In this regard, collaboration of all stakeholders involved – farmers, researchers, farm advisory services, agri and food production business, as well as government representatives is essential to create the synergy.

For many years, IPNI has successfully partnered with other industry groups such as the International Fertilizer Industry Association (IFA), The Fertilizer Institute (TFI), and Fertilizer Canada to promote 4R Nutrient Stewardship. In 2017 IPNI and IFA represented the fertilizer industry in developing the Code of Conduct for the management of Fertilizers initiated by FAO.

Here are more examples from regional IPNI Program activities that illustrate how cooperation between IPNI and stakeholders results in more effective application of research output.

Sincerely,

Svetlana Ivanova, Ph.D.
Vice President, Eastern Europe/Central Asia Group

Dr. Svetlana Ivanova
(center)

Delivering Tools to Empower Smart Farming

IPNI continually works to create a more accurate understanding of plant nutrient management. It is a disservice to farmers and policymakers to allow outdated, overly simplistic, and inaccurate concepts of nutrient behavior to persist. IPNI develops different educational materials to see how stakeholders respond and feedback shows a huge desire for more accurate information. Many have said they appreciate being taught concepts that explain what they had been observing for some time but could not rectify with outdated information. IPNI is continuing to produce and deliver tools to empower those making fertilizer decisions in the field.

IPNI Directors are regularly requested to organize and conduct training on nutrient management strategies using data from the most recent scientific advances. For example, IPNI conducted key training for groups such as the Farming Smarter Field School and the Conservation Learning Centre in Central Canada for hundreds of regional farmers, consulting agronomists, and government specialists. Training sessions based on the principles of 4R Nutrient Stewardship facilitate on-farm adoption of the techniques by building knowledge and confidence of the attendees.

Dr. Tom Jensen,
Director, North America conducting a training workshop.

Dr. Shamie Zingore,
Director, sub-Saharan Africa Program,
explaining new approaches to making
fertilizer recommendations.

Accurate Agronomic Advice

Since 2012, IPNI has built a consortium of over 200 agencies in eight countries in **sub-Saharan Africa** to improve and disseminate plant nutrient management practices in appropriate formats. The resulting materials have been used for training by 125 institutions. Over 20,000 datasets have been assembled to improve regional nutrient management recommendations. The consortium works to empower the fertilizer industry to deliver accurate agronomic advice. Participating companies have benefited from current information and diagnostic tools to better educate their farmer clients. IPNI has now supported the training of stakeholders from 25 local fertilizer companies, 4 regulatory agencies, and 7 fertilizer policy departments in eastern and southern Africa.

Our **China** Program provides important national leadership for plant nutrition research and demonstration. We are trusted partners with many national/provincial-level government institutions, universities, and extension. Our close partnership with the Chinese Academy of Agricultural Sciences (CAAS) provides many opportunities for research, training, mentoring, and scientific exchange. IPNI has been funded to develop the China National Research and Development Project to help cooperators apply Nutrient Expert® for making better fertilizer recommendations. These key relationships provide service to all IPNI members, collectively interested in improving nutrient stewardship.

IPNI China Program Staff in round-table discussions at the Chinese Academy of Agricultural Sciences.

National and international partners meet in Bangladesh to discuss how nutrient recommendations can be improved through the use of Nutrient Expert®.

Strong Partnerships for the Greater Good

IPNI is working with 13 national and international partners to improve the sustainability of crop production in **Bangladesh** through 4R nutrient management. By leading the development of Nutrient Expert®, better fertilizer recommendations can be implemented and promoted in Bangladesh by these influential partners. Cooperation with leading scientific institutions in India on the Soil Health Card database have confirmed the benefits of using Nutrient Expert for making improved fertilizer recommendations and confirm that many soils in the region are deficient in sufficient potassium to support healthy plant growth. Strong partnerships with the national fertilizer association provide many opportunities for training agronomists and extension professionals.

IPNI **North Africa** has developed productive collaboration with many national institutions and organizations. For example, the National Agricultural Research Institute of **Morocco** (INRA) provides support for on-farm trials of wheat and olive fertilization. The Moroccan Office for Agricultural Advice (ONCA) promotes Nutrient Expert® fertilizer recommendations for wheat. Three Ph.D. students are conducting dissertations under the supervision of IPNI.

We partner with the **Algerian** Technical Institute of Annual Crops (ITGC) to demonstrate and promote 4R Nutrient Stewardship, the **Tunisian** National Institute of Annual Crops (INGC) for improving olive tree nutrition, and the **Senegal** Agricultural Research Institute (ISRA) on training and validating Nutrient Expert® for Maize.

Stakeholder training session held by IPNI North Africa Program staff.

Leading the Promotion of 4R

IPNI leads the promotion of 4R Nutrient Stewardship in **Eastern Europe/Central Asia** by working through key national and international partners. IPNI was invited to speak at several prominent conferences to educate more than a thousand industry leaders, agronomists, scientists, farm representatives, and government officials.

This included an invitation to speak at Golden Autumn-2017, the largest agricultural exhibition in Russia. Cooperation with scientific groups has led to the Russian translation of key publications on topics such as micronutrient fertilization, the use of phosphogypsum in agriculture, and improving soybean nutrition.

Dr. Ivanova explains the yield and economic benefits from advanced nutrient management to the audience attending the Golden Autumn-2017 exhibition.

Dr. Fernando García, Director, Latin America-Southern Cone (back row, 6th from right) with lead presenters at the 2017 "Fertilidad" Soil Fertility Symposium in Argentina.

Change Makers

IPNI reaches out to decision makers by actively working in partnership with institutions such as Fertilizar AC, the fertilizer industry association of **Argentina**. For example, the 2017 Fertility Symposium was attended by more than 900 agronomists and farmers. Similarly, IPNI partnered to organize the Symposium of Agriculture in **Uruguay,** with an audience of 450 agronomists and farmers.

In **Southeast Asia,** local demand and export potential for agricultural products pushes the farming frontier into sensitive ecosystems. The opportunity to be more productive on the existing land can be supported through improved plant nutrition through proper use of fertilizers. Our Programs focus on groups that influence change in agricultural practices, such as: 1) integrated industries (e.g., oil palm), 2) buyer groups (e.g., black pepper and cocoa), and 3) public agencies (e.g. rice and maize). For example, our work with the oil palm industry to improve plant nutrition has resulted in 18 peer-reviewed papers, multiple conference talks, four 4R training classes, and new field guide books.

Dr. Oberthür participates in a conference discussing the importance of nutrient management for oil palm sustainability.

Cover of recent IPNI/Nutrientes Para a Vida (Nutrients for Life) publication "Having Fun with the Plant Nutrient Team", which is designed to teach children about the links between healthy food and good crop nutrition.

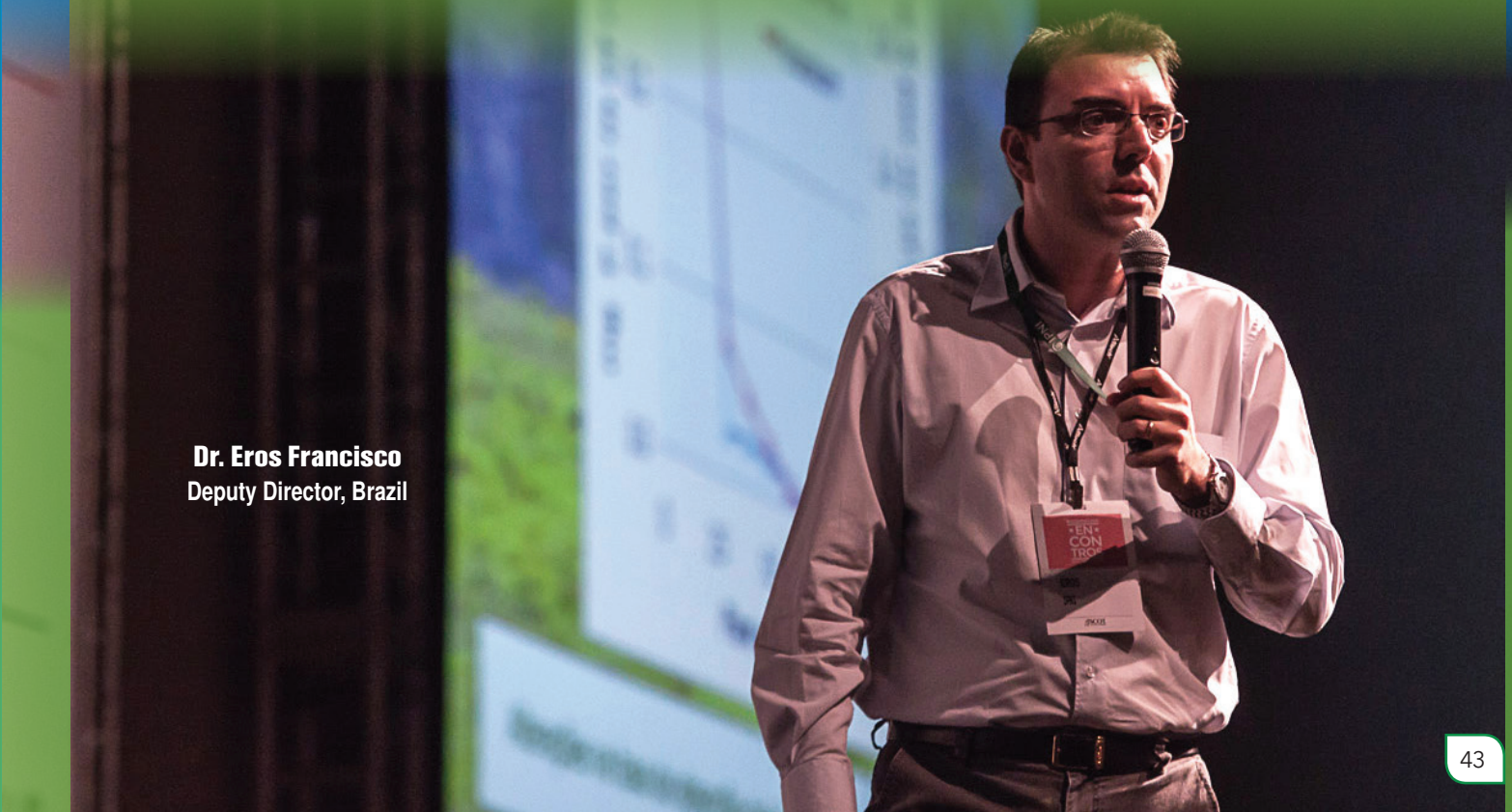
Joining Forces to Educate

As a relatively small organization, IPNI works with influential partners to make a difference.

In Brazil for example, a few key partners include agronomic institutes, farmer-led research associations, universities, and ANDA (the Brazilian Fertilizer Association).

ANDA and IPNI partner for the Nutrients for Life (NFL) initiative in Brazil to inform the public about the many benefits of plant nutrients. Recently NFL Brazil and IPNI translated and published the booklet on "Having Fun with the Plant Nutrient Team" for educating children. More about this initiative can be found at http://brasil.ipni.net/article/horadebrincar

IPNI educates farmers through field demonstrations, day field tours, events, and webinars, among other activities.

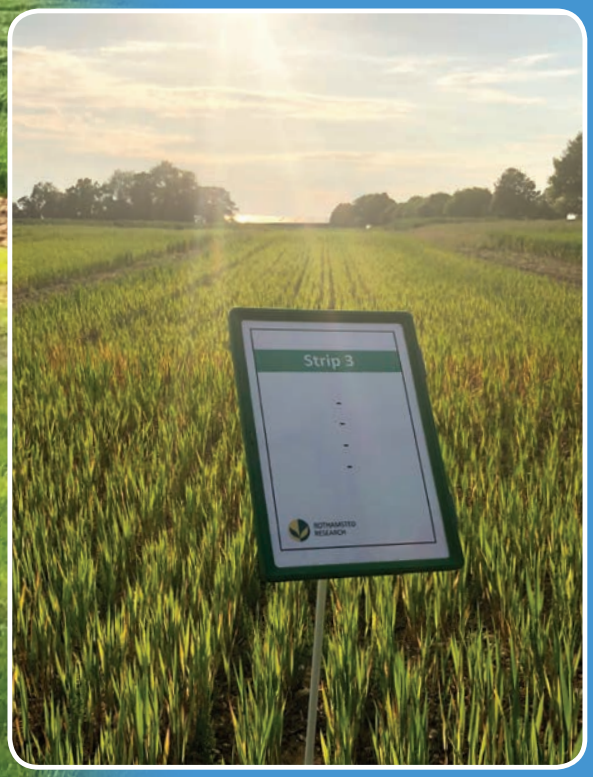


Dr. Eros Francisco
Deputy Director, Brazil

Leading Global Initiatives

The **Nitrogen Program** is advancing sustainable food production through responsible nutrient use. IPNI is a member of Field to Market, which brings together diverse stakeholders from all sectors of the agricultural supply chain in the USA. This program offers credit to farmers for adopting 4R management practices that reduce their greenhouse gas footprint. Our Nitrogen Program works to optimize the beneficial role of nitrogen in food production while minimizing its negative effect on the environment. As such, the program provides leadership to global forums such as the International Nitrogen Initiative.

Dr. Tai McClellan Maaz,
Director, Nitrogen Program



Wheat research with strips of the field receiving inadequate or surplus application rates of nitrogen fertilizer.

A Voice for Agriculture

IPNI Program Directors often represent the plant nutrition industry on various advisory committees. Delivering science-based knowledge into a decision-making process is critical for developing good policy. At many meetings, our Directors are often the only one present to ensure that the voice of agriculture is heard. One example of this effort is in the state of Minnesota, U.S. where our Phosphorus Director, Dr. Heidi Peterson is on the 4R certification technical work group. They are planning nutrient reduction strategies for the **Red River Basin**, which flows north from the U.S. and contributes nearly 60% of the phosphorus load entering Lake Winnipeg in Canada.

Communication Relations

The IPNI Communications Group supports the efforts of all IPNI programs. Its activities intersect all of the objectives of the IPNI Tactical Plan by demonstrating the Institutes's leadership, highlighting its research accomplishments, promoting understanding of sustainable nutrient management, and meeting the needs of IPNI member companies.

EDUCATION MATERIAL:

Our annual catalog highlights many of IPNI's educational materials. While an increasing number of our materials are free to download, selected publications are offered through our store (http://store.ipni.net) and fulfilled by our circulation staff.

INFORMATION SYSTEMS:

IPNI's online presence is managed in-house through our group's expertise. Our website network is designed to allow each IPNI program to self manage their web content with the support of the communications group. Our group extends IPNI news and messages through social media (Twitter, Facebook, YouTube, Instagram, Blog).

Our Media Server (https://media.ipni.net) hosts webinars, presentations, photo/video galleries, subscription services, and access to *InterActions*, our newsletter for our members.

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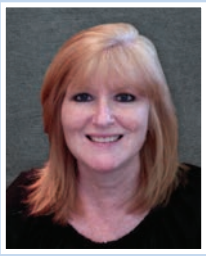

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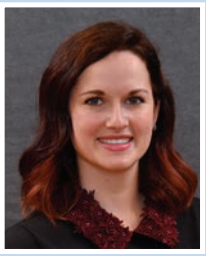

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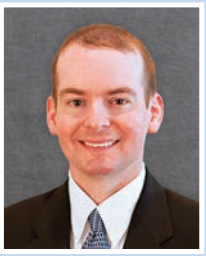

Brian Green
IT Manager
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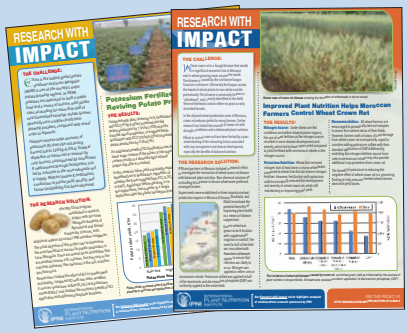
RECENT EXAMPLES

RESEARCH INTERPRETED:

Better Crops - Our flagship quarterly continues to serve as our most recognized venue for delivering agronomic science to the practitioner. This year *Better Crops* was redesigned as a digital magazine that has on-line extras integrated into its pages.



Research with Impact – Monthly series focusing on research solutions to challenges faced.

Plant Nutrition Today – Monthly series that highlights topical issues.

POSITION PAPERS:

Issue Review – In-depth, critical reviews.

Snyder, C. 2017. Progress in Reducing Nutrient Loss in the Mississippi River Basin – But Effects on Gulf Hypoxia Still Lag

Norton, R.M. 2017. Nutrient Use Efficiency and Effectiveness in Australia: Assessing Agronomic and Environmental Benefit

DECISION SUPPORT:

Study Guides/Manuals

- Certified Crop Adviser 4R Nutrient Management Specialist Study Guide
- 4R Plant Nutrition Manual (Turkish)
- Oil Palm 4R Series

Factsheets

Nutri-Facts Series (Arabic and Australian/New Zealand editions)

Booklets

Mineral Nutrient Deficiencies in Cereals (Spanish)
Plant Nutrition Diagnostics (Potato)

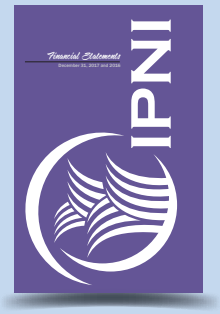
About IPNI:

InterActions

Annual Report

Regional Reviews

Briefing Notes



Financials

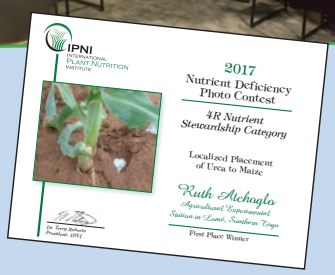
Distance Education: Webinars & Videos

MEETING SUPPORT:

Pre/Post Conference

SPECIAL EVENTS:

Global Fertilizer Day
Photo Contest
Exhibits

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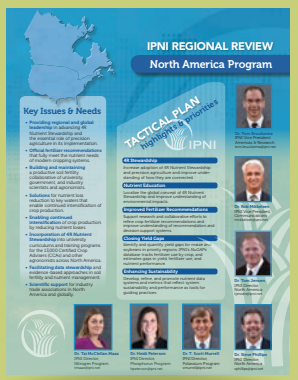

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Thank You for Your Service!

Many of our long time, dedicated staff who have played instrumental roles in the development of the Institute, retired from IPNI in 2017. Their brilliance and expertise have made our Institute what it is today. It is with great appreciation that we acknowledge their service.

Dr. Paul Fixen | 1989-2017
Senior Vice President & Director of Research

Phyllis Pates | 1996-2017
Secretary

Dr. Armando Tasistro | 2009-2017
Director, Mexico & Central America

Dr. Cliff Snyder | 1995-2017
Director, Nitrogen

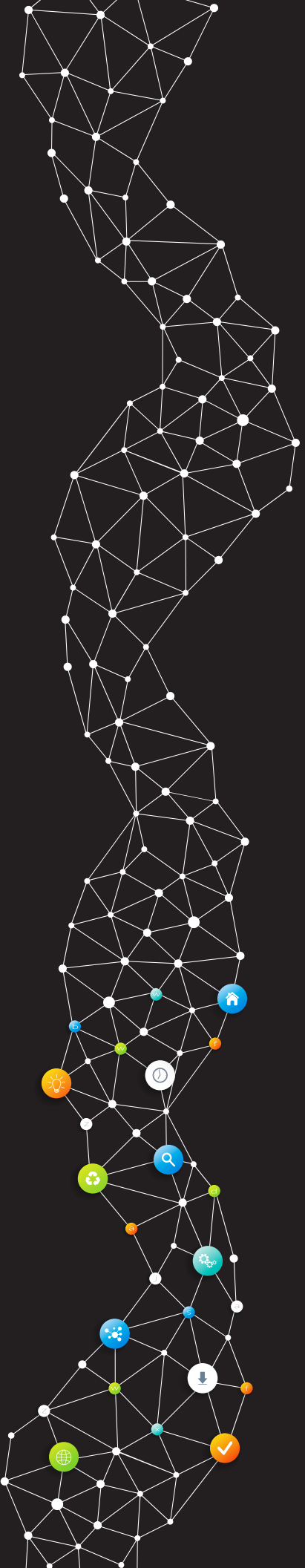
Dr. William (Mike) Stewart | 1996-2017
Director, North America

Dr. Shihua Tu | 1998-2017
Deputy Director, China

Dr. Munir Mohammad Rusan | 2007-2017
Consulting Director, Middle East

Dr. Valter Casarin | 2009-2017
Deputy Director, Brazil

Dr. Rob Norton | 2009-2017
Director, Australia/New Zealand



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