IPNI
Plant Nutrition TODAY
Better Crops, Better Environment...through Science

From Scientific Staff of the
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THE SOCIAL IMPACT OF 4R NUTRIENT STEWARDSHIP

The social dimension is one of the three major pillars of sustainability. Sustainable plant nutrition means applying the right source of nutrients at the right rate, at the right time, and in the right place. How does 4R Nutrient Stewardship engage the social pillar? What impacts can we expect on social conditions?

Often, nutrient practices do not seem to be related to social conditions. For example, an improvement in fertilizer placement might increase profits from corn production and reduce losses of nitrogen and phosphorus, but do we really expect it to change social conditions directly? Possibly, if the nutrient source smelled foul (some do!), the change might lead to better neighbor relations and improved quality of rural life - direct social benefits. But additionally, considering long term and broad scale adoption, the two improvements in economic and environmental impact add up to more worldfood supply with more and better natural surroundings for people to enjoy. Isn't that too a social benefit?

Social benefits also arise from the sustainable intensification that the 4Rs support. Much of North American agriculture is becoming more extensive than intensive. Larger and faster equipment, on the one hand, allows better timeliness in planting and other field operations, and improved labor productivity, but on the other hand, it may enable a tendency to manage larger land areas without addressing their site-specific crop nutrient needs. A 4R Nutrient Stewardship approach emphasizes ensuring that each crop in each field receives the right source of nutrients at the right rate, time and place. Tools of precision agriculture—including precision nutrient placement for conservation tillage systems—enable intensive approaches on extensive areas, generating employment opportunities that didn't exist before.

4R Nutrient Stewardship demands adaptive management. While an operator can now cover more acres in a day, that operator needs to be supported by more local site-specific information. Generating that information requires adaptive management—continuous systematic assessment and participatory learning. Adaptive management requires investment in people. Engaging crop advisers and agronomists for 4R advice, certification consistency, and help in record-keeping creates demand for well-educated service providers. Participating in adaptive management builds a sense of teamwork. The cycle of evaluating practices for their economic and environmental impacts engages people to work together. All this put together builds a more interactive social environment.

4R Nutrient Stewardship also demands accountability. The ability to communicate in a simple manner to the many stakeholders of agriculture—neighbors, consumers, environmental advocates—is important for ensuring that public perception supports public policy that enables continuing intensification. Communication is a task that requires skills and training, but is most effective when it's done by the people involved in what's happening. Supporting such communication is an investment toward greater sustainability. The goal-setting part of a farm's 4R Nutrient Stewardship plan brings farmers and crop advisers into contact with people they might never have encountered otherwise. Displaying the logo and sharing its associated information informs public opinion and educates consumers.

Finally, 4R Nutrient Stewardship supports maintaining soils for the benefit of future generations. The success of today's agriculture owes a lot to what previous generations have invested in improving the fertility and conservation of the soil. Replenishing nutrients removed, maintaining organic matter, and sustaining soil biology matter to future generations.

Sound nutrient stewardship delivers benefits, socially as well as economically and environmentally.

– TWB –

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MYCORRHIZAE FUNGI AND HOW THEY ASSIST MANY CROPS TO ABSORB NUTRIENTS

There is a lot more than just plants that live and grow in soil. Soil inhabiting organisms include a diversity of types and sizes. There are small burrowing mammals, insects, amphibians, and worms that can be seen with our eyes, and also a large diversity of tiny and microscopic biota including nematodes, bacteria, fungi and actinomycetes. All of these organisms work to breakup, disperse, incorporate into the ground and decompose plant residues. They also in many instances help to weather soil mineral components and less soluble precipitated compounds. All this activity results in the release of plant nutrients in mineral forms that plants can use to grow. The whole process of nutrients being used by plants, and then plant residues being decomposed in soil is a vital part of nutrient cycling in the environment.

The majority of the nutrients in soil, at any one time, are stored in forms that are unavailable to plants. At first this sounds less effective, but is in fact a necessary feature of soils so that nutrients are stored and released in a timely and adequate manner, but not so soluble that they would be easily leached out of soils. Plant roots exude chemicals that help to dissolve some of these more complex and less soluble compounds that contain plant nutrients. However, plants are not able to do this all on their own, and this is where other soil-inhabiting organisms, noted above, help out. One especially effective and beneficial group of microbes is a genus of fungi called Mycorrhizae (*M*). These fungi have the ability to grow into the roots of many plant species, while their fungal hyphae or branches grow into the soil matrix.

***M* fungi are beneficial to many important agronomic crop species in a couple of ways.** They live symbiotically with the crops by accessing and supplying needed plant nutrients from the soil to their plant partner. The plant in turn shares photosynthetically produced sugars to the fungi as an energy source. The *M* fungi make nutrients accessible to crop plants by first effectively increasing the extent of the plant root system in soil by exploring portions of the soil that the roots would not grow into and touch. Secondly, they have the ability to dissolve low solubility compounds containing plant nutrients, that crop roots are less effective at doing. Because many plant nutrients have low mobility in soil, they diffuse slowly and for only a short distance, for example a few millimeters in a growing season, from an area of higher concentration to an area of lower concentration. It is very helpful to have the *M* hyphae assist in finding and acquiring needed nutrients. In these two ways they help supply nutrients to crops, especially less mobile phosphorus, potassium, and most micronutrients.

Management of cropping systems by choosing certain crop rotations and reduced tillage systems can help *M* fungi to be more effective. Even though in the original natural state many of the grassland soils of the Northern Great Plains contained a diverse group of *M* fungi species the use of intense tillage, summer fallowing, and predominately growing wheat, has drastically reduced the number of *M* fungi species surviving. The remaining species cannot supply needed plant nutrients as well compared to if more species would be present. However, by using conservation or no-till cropping, and a more diverse crop rotation including pulse crops such as lentils and field pea in rotation along with small grain cereal crops, it is possible to create soil conditions suitable to re-establish many beneficial *M* fungi species.

There is on-going research in the Northern Great Plains on how to bring back the beneficial influence of missing *M* fungi for growing crops. Research is being led by Dr. Chantal Hamel, Director of the Soil Microbiology Laboratory, Semiarid-Prairie Agricultural Research Centre, of Agriculture and Agri-Food Canada, Swift Current, SK. Dr. Hamel's research team is selecting beneficial missing species of the fungi, still present in natural grasslands, and reintroducing them into cropped soils. Part of the technique to achieve this is to successfully grow the needed species in sufficient quantity under controlled laboratory conditions, inoculate the seed of a compatible crop species, e.g. a pulse crop, and grow this crop in rotation with wheat. The use of no-till planting and cropping helps the reintroduced fungi to survive, as tillage itself is disruptive to established fungal hyphae in soils. Many of the so called "lost" species of *M* fungi will increase nutrient availability to crops, after reintroduction using less tillage, cessation of summer fallowing, and growing diverse crops in rotation.

– TLJ –

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CROP NUTRITION PROBLEMS CAN BECOME PEST PROBLEMS

We are familiar with the concept of preventative medicine, where health problems are avoided by good practices instead of curing sickness after they occur. This same concept applies to damage caused to crops by plant diseases and pests when adequate and balanced nutrition is lacking.

Each nutrient in plants has unique and specific functions that operate in an intricate balance of physiological reactions. A deficiency of a single nutrient will result in stress that impairs healthy plant growth. Until the symptoms of deficiency stress become visible, the hidden roles of proper nutrition in maintaining plant health are too frequently overlooked.

New scientific studies are again confirming what farmers have known for many years about the link between plant health and nutrition. Healthy plants can generally withstand stress and attack better than plants that are already in poor condition. For example, recent work with corn has demonstrated the link between an adequate K supply and increased leaf thickness, stronger epidermal cells, and decreased leaf concentrations of sugars and amino acids. All of these factors lower the attractiveness of plants for pests, such a spider mites.

The link between adequate K and soybean aphids has also been recently reconfirmed. Research shows that K-deficient soybeans tend to transport more N-rich amino acids in the phloem, making them a favored target of stem-sucking aphids.

The link between plant nutrition and disease control generally falls into one of these categories where proper fertilization can:

<u>Reduce pathogen activity:</u> Proper mineral nutrition can slow or inhibit the germination and growth of a variety of plant pathogens in soil and in plant cells.

<u>Modify the soil environment:</u> The selection of a N source can temporarily modify the rhizosphere pH during critical periods between germination and seedling establishment. Likewise, the addition of elemental S is a common practice to acidify the root zone of some crops for disease control.

<u>Increase plant resistance:</u> Healthy plant tissues are less susceptible to infection. Proper nutrition can stimulate the production of physical and chemical defenses to cope with pathogens.

<u>Increase tolerance to disease:</u> Adequate nutrition can help plants compensate for disease damage and to sustain a high level of natural compounds that inhibit pathogen growth within plant tissue.

<u>Facilitate disease escape:</u> Plants that are adequately fertilized with boron (B) and zinc (Zn) have been shown to have fewer fungal spores that break dormancy on the roots, compared to deficient plants. A healthy photosynthetic capacity also allows for a quick growth response to a pathogen invasion.

<u>Compensate for disease damage:</u> An adequate supply of plant nutrients is closely linked with vigorous root growth and photosynthetic activity. These healthy plants can better tolerate increased disease burdens than plants stressed by nutrient deficiency.

Nutritional and environmental stresses often trigger greater pest and disease damage to crops. While proper fertilization does not eliminate the risk of pests and diseases, it provides an important degree of protection from many yield-robbing factors.

Effective disease and pest management through proper plant nutrition improves crop quality and contributes to provide a safe, abundant, and nutritious food supply.

– RLM –

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Abbreviations: N = nitrogen; P = phosphorus; K = potassium, S = Sulfur.

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MOBILE DEVICE TECHNOLOGY IS LEADING THE WAY TOWARD "SMART" FARMING

For the second year in a row, smart devices lead the way in the annual PrecisonAg.com Tech Top Five survey. There are many reasons why the use of mobile device technologies (smart phones, tablets, etc.) in agriculture is growing rapidly. The most obvious reason is that most people already have one. Anytime a tool that users are already familiar with can be used to enhance farm management, adoption will be rapid. Other reasons include the ease of telemetry and data transfer and the fact that internet connectivity is improving rapidly in rural areas, which was an issue for agricultural use a few years ago.

Another driver for adoption is the recent explosion in agricultural applications (apps) for mobile devices. Some of the apps are downloadable and some are Internet browser-based, but all of them make it possible for users to have access to more information than ever before. In the PrecisionAg.com article, Jeremy Wilson, technology specialist for Crop IMS, said the "development of these [agricultural] apps will allow a service provider to bring new value to growers in ways not even considered just a couple of years ago."

Dr. Brian Arnall, precision ag extension specialist at Oklahoma State University, gave an extensive overview and workshop on agricultural apps at InfoAg 2013. Dr. Arnall has reviewed approximately 85 apps over the past year and demonstrated several features of some that he found to be most useful for agricultural practitioners. He also identified a few basic ways that various apps can be categorized, including news, weather, and market updates, identification tools, simple calculators, scouting tools, and input selection calculators.

Among the identification tools, Dr. Arnall found one of the most comprehensive to be the IPNI Crop Nutrient Deficiency app. The IPNI app includes a range of nutrient deficiency photos for 14 prominent crops. Text and diagrammatic descriptions are also provided. Another very useful tool in the i.d. category is ID Weeds, developed by Dr. Kevin Bradley at the University of Missouri. ID Weeds lets the user select the weed from an image database or by progressing through a series of morphological queries via a user-friendly drop-down menu.

Simple calculator apps can be used to estimate growing degree days, nutrient removal in harvested crops, harvest loss, and plant populations. IPNI has recently developed a web-based nutrient removal app available in six languages and English or metric units. The app includes N, P, K, and S removal for 60+ crops at a user-defined yield level, with plans to expand to over 90 crops and other nutrients. The IPNI nutrient removal app can be viewed at http://ipni.info/calculator.

Scouting tools are comprehensive field-guide apps that place a wealth of information in the hands of growers and crop advisors. One of the best scouting apps, according to Dr. Arnall is the Corn Advisor app developed at the University of Arkansas. Corn Advisor includes nutrient, disease, and pest i.d. image databases, lime and nutrient rate calculators, and the complete UA Corn Production Handbook.

To view Dr. Arnall's complete review of agricultural apps, visit his blog at http://OSUNPK.com. Also, make plans to attend the next InfoAg July 29 – July 31 at the Union Station Hilton in downtown St. Louis, MO. Featured topics will include the latest trends in mobile device technology, variable-rate seeding and fertilization, zone management, robotics, UAVs in agriculture and many others. Stay informed by visiting www.infoag.org and following @InfoAg.

– SBP –

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Abbreviations: N = nitrogen; P = phosphorus; K = potassium; S = sulfur.

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ADAPTING TO CHANGE – DOES YOUR NEIGHBOR NEED A NUDGE?

It is often heard that the world around us is constantly changing, and that if we are standing still, …. well …. then we are getting behind. Indeed, farmers today are immersed in the challenges of a global agricultural economy. What happens on the opposite side of the world may have an increasing and sometimes dramatic impact on each of us locally.

Like the certainty of death and taxes, …. two things that every farmer can also be certain of are changes in crop prices and changes in the weather. Fluctuations in precipitation and changes in temperature at some places in the last decade or two seem to be greater than what we may remember from the past. Some of the manifestations of those changes are being reported by some federal and state agencies as increased loading or delivery of N and/or P to streams and other water resources: possibly a result of some of the rainfall extremes, but perhaps also associated with crop and soil management practices and their impacts. How does one prepare for uncharted changes in growing conditions, or the risks of nutrient losses from fields, which are difficult–if not impossible–to accurately predict?

In the face of the record drought of 2012 and the record spring rainfall of 2013, some in the central U.S. anecdotally observed that crops produced on fertile soils, which possessed good soil organic matter levels and good tilth, seemed to fare better and were more resilient. In addition to the blessing of good soils, some farmers experienced benefits to changes in the way they traditionally applied their nutrient inputs. Crop N sensors enabled many to respond to the environmental conditions by applying less or more inputs, and at more optimal timing. Other farmers observed less runoff loss of nutrients when inputs were applied beneath the soil surface; either by subsurface banding or some soil tillage incorporation. An important corollary to the well-recognized statement by Franklin D. Roosevelt—"A nation that destroys its soils destroys itself"—is the fact that proper management and improvement of soil fertility and soil productivity may preserve and sustain the human family (especially during trying environmental conditions).

Many of us do a fair job of evaluating what has been done in the past, on our own land, yet we often hear coffee shop comments like, … "that neighbor needs to sharpen her/his skills and plan a little better next year." Increasingly, such neighborly observations are resonating all the way to Washington, DC and farmers are expected to do a better job of getting more and more of their applied nutrients into the crop, while allowing less and less to escape their fields. Many farmers today are doing a much better job than in the past, …. but still there may be others who need a "neighborly nudge" to initiate beneficial soil and cropping system management changes. Some of the largest challenges for implementing adaptive management and changes in farming practices may be associated with more and more land being rented or leased, as opposed to being owned by the farmer/operator. Complexities of some ownership scenarios may hinder openness to trying new and different practices, or receptivity to management changes that sometimes are best cost-shared between landowners and renters.

To successfully adapt to change, and achieve the soil and nutrient stewardship increasingly expected—or required—by society, what nudging do our "neighbors" need?

– CSS –

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Abbreviations: N = Nitrogen; P = Phosphorus.

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FERTILIZATION AND CROP PRICES

Changes in crop prices often generate questions about the economics of fertilization. Prices for many crops, particularly corn, have recently fallen considerably from the highs of the past few years. This shift has some asking questions such as, "should I reduce fertilizer rates in response to lower prices?" A detailed answer for a specific situation will depend on several factors, but a review of some fundamental principles can give us a foundation for addressing such questions.

There are four primary factors affecting profitability…crop price, production costs, yield level, and crop quality (as it affects price). Now, which of these factors does the grower have significant control over? Typically, producers are price takers and thus have little control over prices. However, they do have control over variable costs, which directly impact yield and quality. Thus, in this sense yield level is a controllable factor determining profit. Once a decision has been made to plant a certain crop then it becomes a simple matter of making the most of the opportunity. This requires planning a program designed to optimize efficiency and produce maximum returns per acre... in other words, to produce yields that maximize profit while exercising responsible environmental stewardship.

Greater profits come from higher yields (to a point) since costs are spread over more production units (bushels, bales, pounds, etc.) resulting in lower cost per unit of production. Efficient and profitable production involves lowering unit cost to a point of maximum net return. This MEY (maximum economic yield) concept was popular decades ago, and is as valid and legitimate today as it was then.

Crop and fertilizer prices have relatively little effect on optimum levels of fertilization. This is because in determining profitability yield level has an overshadowing effect on crop and fertilizer price. Economists at Kansas State University (KSU) have published an online Excel tool (KSU-NPI_CropBudgets.xls, at http://www.agmanager.info/crops/prodecon/decision/default.asp) that helps demonstrate the impact of crop and fertilizer prices on estimated economic optimum rates of both N and P application. For irrigated corn with yield goal set at 250 bu/A, N and P_2O_5 prices set at $0.50/lb, and all other settings left at default, when crop price was varied from $7.00 to $3.50 the estimated optimum N rate went from 340 lb N to 308 lb N/A—a decline of 32 lb N with a halving of corn price. For P the rate dropped from 34 to 27 lb P_2O_5/A—a decline of only 7 lb. This example is meant solely for illustrating that while shifts in crop prices do have an impact on optimal rates of application, that impact may not be nearly as great as one would first expect. Therefore, the tendency to react to crop price declines by deeply cutting inputs should be closely scrutinized.

Adequate and balanced fertility may also produce non-yield profit affecting benefits. For example, in a KSU irrigated corn study (Dhuyvetter and Schlegel, 1994) P fertilizer hastened maturity, lowered grain moisture at harvest, and resulted in greater profit due to lower drying cost. This work showed that P fertilizer reduced drying costs by an average of $0.10/bu.

Farmers and their advisers are more than ever operating in a fluid global environment. Adaptation to massive swings and changes is necessary for survival; however, even in the face of change certain principles endure. One of these is the MEY principle discussed above, another is the principle of 4R Nutrient Stewardship. This brief piece has discussed the effect of crop price on estimated optimum fertilizer rate. But none of the 4Rs (fertilizer rate, source, time and place) stands alone; all are interconnected, each affecting the other. An MEY program requires not only the right rate, but also source, time and place factors that collectively assure efficient and effective nutrient use.

– WMS –

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Abbreviations: N = nitrogen; P = phosphorus.