Can we define a global framework within which fertilizer best management practices can be adapted to local conditions?

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The title of this paper is not a statement, but rather a question, and it does not ask "Can I define a global framework …" but rather can we define a global framework. As such, no attempt to answer the question will be made in this paper. It is assumed that "we" refers to the global fertilizer industry and that, if a meaningful global framework can be defined and should be defined, the discussions of this meeting should offer an opportunity to do so or at least to start the process. "We", as a global industry, will need to determine whether a global framework within which fertilizer best management practices (FBMPs) can be adapted to local conditions can be defined.

So if this paper will not answer the question of its title, what will it attempt to accomplish? The following issues related to definition of a global framework will be discussed with the hope of facilitating later deliberations at this meeting:

- challenges in defining a global framework,
- potential foundation for a global framework,
- potential benefits to the industry of a global framework.

Challenges in defining a global framework

Definition

The first challenge to address is perhaps the definition of best management practices (BMPs). Many definitions over the last two decades have been offered for BMPs, with emphasis varying depending on the primary interest of the definer. Examples across a range of interests follow:

1. USDA-ARS (Sharpley *et al.*, 2006) – Best management practices include soil and water conservation practices, other management techniques, and social actions that are developed for a particular region as effective and practical tools for environmental protection.
2. FDCO and FAO (Tandon and Roy, 2004) – A set of agronomic and other soil-crop management practices, which lead to the best possible use of applied inputs for crop production, resulting in minimal adverse effect on the environment. A pre-requisite for efficient and environment-friendly fertilizer use. Important for all soils, crops and fertilizers.
3. BMP Challenge (Anonymous, 2006) – BMPs are designed to save you money by using your field history and soil test results to cut fertilizer costs and maintain yield.

4. North Carolina State University (Lilly, 1991) – Farming methods that assure optimum plant growth and minimize adverse environmental effects.
5. PPI (Griffith and Murphy, 1991) – Practices which have been proven in research and tested through farmer implementation to give optimum production potential, input efficiency and environmental protection.

The first definition clearly emphasizes environmental protection without mentioning production or profitability. The second is more inclusive, referring to “best possible use of inputs” but the specific meaning of such an expression is unclear. The third definition is part of an incentive program designed to reduce fertilizer use and this definition certainly reflects that focus, while admitting that the best you could hope for by following these practices is yield maintenance, an objective likely falling far short of future demands agriculture must meet. The fourth explicitly mentions the need for the practice to provide optimum nutrition to the crop along with environmental protection. The last definition was offered by fertilizer industry representatives and has a stronger emphasis on practicality and productivity while including efficiency and environmental protection. I admit a bias towards the latter two definitions because they incorporate a primary objective of fertilizer use … economically optimum crop production built on well-researched principles.

Limiting technical breadth without limiting usefulness

Another challenge involved in defining a global framework for fertilizer BMPs is defining the technical breadth of that framework. Darst and Murphy (1994) wrote about the lessons of the U.S. Dust Bowl coupled with thousands of research studies showing the merits of proper fertilization and other new production technology, catalyzing the fusing of conservation and agronomic BMPs. The challenge is to address the specific BMPs dealing directly with fertilizers while recognizing the myriad agronomic and conservation practices with which the fertilizer practices interact.

Science and experience clearly show that the impact of a fertilizer BMP on crop yield, crop quality, profitability and nutrient loss to water or air is greatly influenced by other agronomic (plant population, cultivar, tillage, pest management, etc.) and conservation practices (terracing, strip cropping, residue management, riparian buffers, shelter belts, etc.). Practices defined with sufficient specificity to be useful in making on-farm fertilizer use decisions, often are “best” practices only when in the appropriate context of other agronomic and conservation BMPs. A best fertilizer practice can be totally ineffective if the cropping system in which it is employed has other serious inadequacies.

The title of this paper limits the breadth of its discussion to fertilizer BMPs in contrast to nutrient BMPs, which is a broader topic. Nutrient management BMPs include livestock manure management and practices designed to capture nutrients before they are lost from the agro-ecosystem, such as cover crops, crop residue management, contour planting, field buffer strips and controlled drainage. These practices, that extend beyond fertilizer management, are often essential for farmers to accomplish many of the objectives of nutrient management, especially those related to the environment. Focus on fertilizer BMPs should not be taken as diminishing the importance of these other nutrient management practices. As mentioned earlier, failure to follow BMPs in these other areas can cause failure of fertilizer BMPs as well.

An important aspect of creating a global framework is knowing how "deep" or detailed the global version should be. On the one hand, too much detail could overly constrain the appropriate site specificity of BMPs and involve technology implications that cannot be generalized across a global scale. On the other hand, an overly general framework would give insufficient uniformity to the resulting fertilizer BMPs. This would prevent full realization of the benefits of showing the global support of the fertilizer industry for a meaningful BMP concept. Another consideration is the need for companies to show unique value in the market place. If the "sameness" from a framework goes too far, some might argue that a company's ability to deliver unique value becomes compromised.

Targeting a specific audience

Descriptions referred to as BMPs occur at all levels of scale and specificity. At one end of the spectrum you have "Apply fertilizer according to annual soil test recommendations. Do not apply more fertilizer than is recommended. Apply fertilizer to actively growing crops only (NCSU, 2007)." This is the only reference to fertilizer management in a university publication on BMPs. However, the same institution has another publication on BMPs that includes four pages of fine print, with numerous references to additional publications covering the details of specific nutrient BMPs (Lilly, 1991). Clearly the audience for the first publication was not the same as the latter. Both have utility, with the first intended for communication of the general aspects of BMPs to a non-technical, non-practicing audience, while the latter would be meaningful to farmers or their advisers.

To be most effective, the presentation of a global framework for fertilizer BMPs would need to be directed to a specific audience. A single complete framework could be developed with sufficient detail to serve as the skeleton for site-specific, detailed local practices where the target audience is the farmer and the farmer's advisers. However, a much more compressed but visual presentation of the same framework might be in order for non-technical communication with policy influencers and the general public.

Potential foundation for a global framework

Science-based principles

A global framework would likely be built with the science-based principles that lead to the best practices. The principles would serve as a guide to practices with the highest probability of accomplishing the objectives of fertilizer management. Those objectives were described by Roberts (2007) earlier in this workshop, as application of the right product, at the right rate, at the right time and in the right place. It is essential that these practices be presented as offering the **highest probability** of accomplishing the objectives rather than **guaranteeing** that the objectives will be accomplished. Figure 1 illustrates the complexity of the cropping systems in which fertilizers are managed. Many of the factors markedly influencing plant growth, metabolism and nutrient needs are uncontrollable, resulting in considerable uncertainty as to what the right form, rate, placement or timing will be at a specific site in a specific growing season. The best the manager can do is to adopt those available practices that have the highest probability of leading to the right fertilizer management decisions. Science allows us to define those practices.

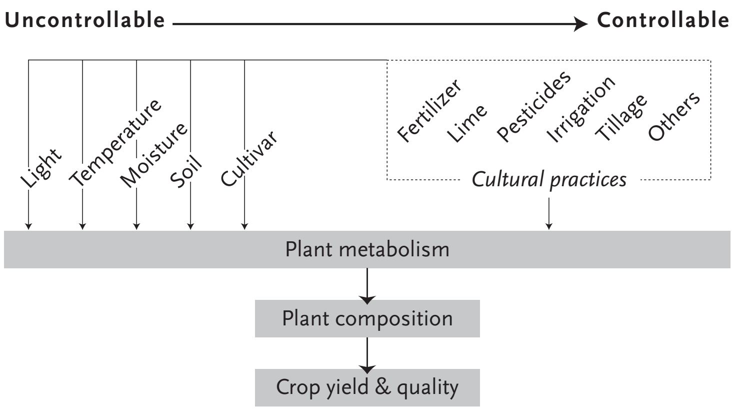

Figure 1. A complex system involving uncertainty (After Beaufils, 1973).

Tested through farmer implementation

However, science-based knowledge offers only part of the foundation for the fertilizer BMP framework. The other part is referred to in BMP definition 5 above - «tested through farmer implementation». Science can lead at times to practices which simply are not workable on real farms. For example, the time or labor requirement may be too high, or one apparent BMP may be in conflict with another BMP. Therefore, an element of practicability must be part of the foundation; the most assured evaluation of practicability is testing on real farms.

Flexibility in the framework

Scientific truths are seldom permanent but change as scientific knowledge grows. Likewise, BMPs are dynamic and evolve as science and technology expands our understanding and opportunities and practical experience teaches the astute observer what does or does not work under specific local conditions.

Figure 2 illustrates schematically how science-based decision support tools can facilitate the integration of multiple site-specific factors into a prediction of the right product, rate, time and placement. That prediction leads to a management decision and associated action. With time, the economic, agronomic, environmental and resource impacts of the action are known, and that experience is fed back into the decision making process, allowing for better future predictions of right product, rate, time and placement.

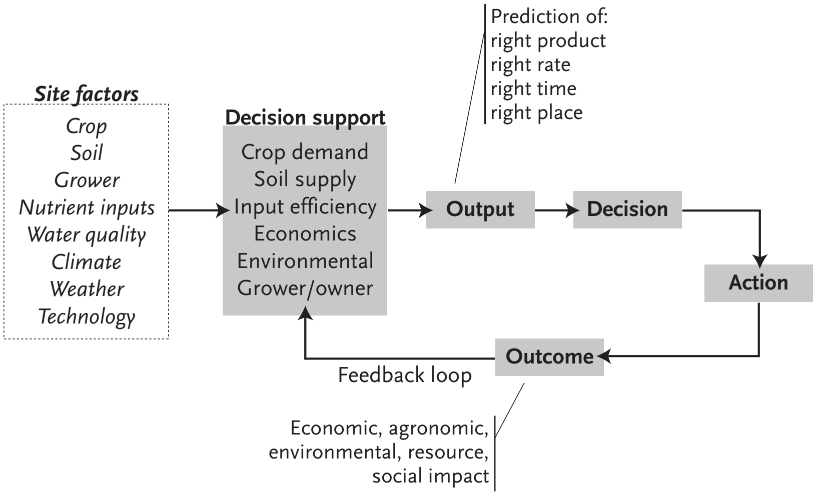

Figure 2. Decision support leading to fertilizer BMPs as a dynamic process requiring local refinement (After Fixen, 2005).

Consideration of the many possible site factors that can influence the exact nature of fertilizer BMPs reveals why local flexibility is essential. For example:

- **Crop factors** usually include yield potential and crop value and in some cases tissue nutrient concentrations or leaf color, as well as several crop cultural practices that can influence nutrient management;
- **Soil factors** often involve soil nutrient supplying indices or other physical, chemical or biological properties that influence nutrient cycling and crop growth;
- **Grower factors** might include land tenure, availability of capital, opportunity costs, the experience/education of the farmer and local advisers, or philosophical nutrient management objectives;
- **Nutrient input factors** incorporate information on sources available such as commercial forms or nutrient-containing wastes, fertilizer costs and application costs;
- **Water quality factors** might include restrictions on nutrient application in riparian zones or near other water bodies or considerations due to ground water quality;
- **Climate factors** drive some types of model-based support systems while others respond to near real-time weather information for a specific growing season and short term weather forecasts;
- **What relevant technologies** are available at the site in question may certainly influence definition of best practices. For example, in-season refinement of N application rate and timing may be best accomplished with electronic sensor technology in some cases, and leaf color charts in others.

The dynamic nature of site-specific fertilizer BMPs and the importance of local flexibility present a significant challenge to mandated fertilizer BMP adoption. Mandates may speed adoption, but may also result in loss of beneficial fine-tuning based on local expertise.

An example of a partial global framework

So, what might a global framework actually look like, considering the challenges and essential characteristics previously discussed? Several approaches could be taken. One possibility is outlined in Figure 3. This framework has five parts – goals, objectives, principles, practices and assessment. The first three parts are considered global while the fourth and fifth are considered local.

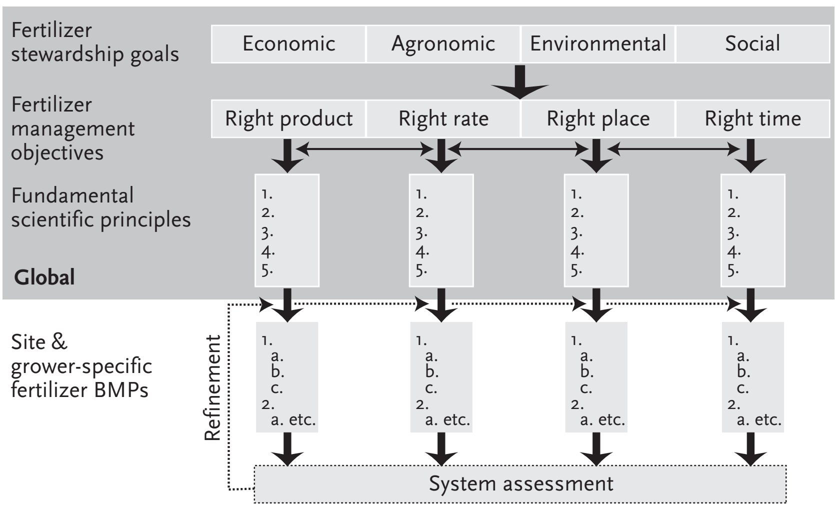

Figure 3. One potential global framework from which fertilizer BMPs can be adopted.

- **Fertilizer stewardship goals**. It is important that the industry should clearly articulate these goals to the public and that we have them in front of us as we go about our daily business. Most organizations already have developed their own stewardship goals and the task here is to connect the goals the industry shares with the other components of the framework … show that we do practice what we preach. Often only three categories of goals are shown but in this case "agronomic" has been included to allow emphasis on the interaction of fertilizers with other factors of crop production.
- **Fertilizer management objectives**. The "rights" have been discussed elsewhere. The horizontal arrows connecting the fertilizer management objectives illustrate that considerable interaction exists among the four objectives. For example, the right timing and placement is often influenced by the product being used. And the rate is likely to be right only if the product, placement and timing are appropriate. All four objectives are met or not met as a set since a system is what exists in the field.
- **Fundamental scientific principles**. These were also discussed earlier and, in this framework, they serve as the conduit between the global segment of the framework and site and grower-specific fertilizer BMPs. For the most part, current BMP litera-

ture does not link recommended practices to the scientific principles behind them as shown here. This is a critical void since these principles are the foundation local advisers use to refine generalized BMPs for local conditions. They are essential for maintaining the flexibility to truly create site and grower specific BMPs. The intention of the framework is that the principles should be stated in such a way that their application is universally essential to define fertilizer BMPs, regardless of local conditions.

- **Site and grower-specific fertilizer BMPs**. These are actions that can be practiced by farmers and their service providers or advisers. They are therefore very specific. A couple of examples of fertilizer BMPs related to the "right rate" objective are shown in Figure 4. Five principles are listed under "right rate" with the first being to assess soil nutrient supply. A universal need for determination of "right rate" is some assessment of the soil's ability to supply the nutrient in question. If sufficient research supports the tests and laboratory access exists, appropriately conducted soil testing is a BMP based on that principle. In other cases, omission plots may be more appropriate. The appropriate target level for the soil test is influenced by several soil and farmer-specific factors, and may also be influenced by water quality considerations.
- A**ssessment**. As in the process model outlined in Figure 4, local feedback is important for the refinement of site- and grower-specific BMPs. Since the objectives of fertilizer management are met or not met as a set, the system is assessed rather than the practices associated with individual management objectives. In many regions a need exists for clear guidance on appropriate system assessment methodology to evaluate progress in attaining fertilizer stewardship goals.

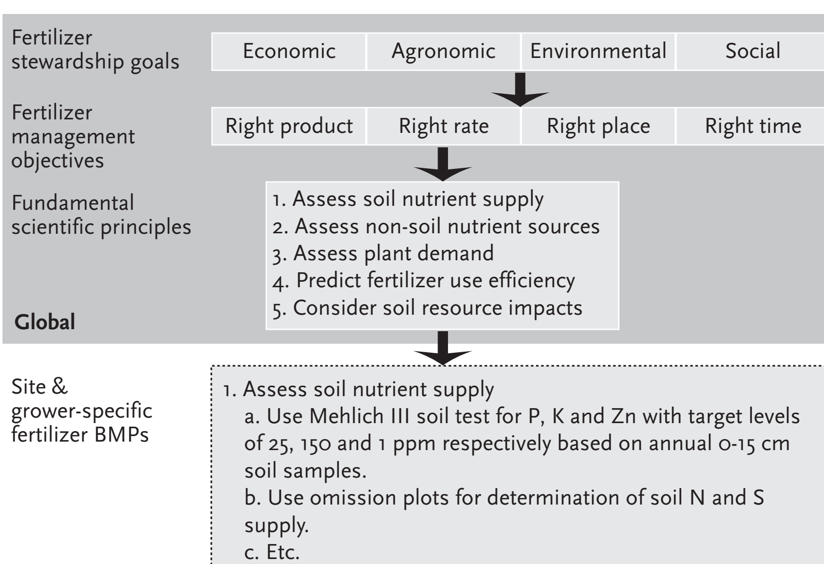

Figure 4. One potential global framework with fertilizer BMP example.

Potential benefits to the industry of a global framework

What incentives might exist for the industry to develop a global framework for fertilizer BMPs? If no such framework is adopted, those individual companies, countries or regions that perceive value in defining, promoting and evaluating fertilizer BMPs will continue do so with or without such a framework. So, why bother?

Several potential benefits of a global framework come to mind:

- **A better framework**. If one believes in the collective intelligence of multiple technical experts from diverse backgrounds working on a common problem, all should benefit from the high quality product resulting from such an effort. We start the process of establishing site-specific fertilizer BMPs at a better place.
- **The power of a unified voice**. An entire industry speaking the same language concerning fertilizer BMPs and its support of them should be more effective at clearly communicating, internally and externally, sustainability issues related to economic, agronomic, environmental and social performance.
- **More effective use of science and technology**. The science-based principles of nutrient cycles, soil fertility and plant nutrition are universal. How they manifest themselves in specific management practices varies with climate, soils, access to technology, local economic conditions and culture. However, the global soil map (Figure 5) reminds us that there is predictable order in soils that can be invaluable in helping to define the global inference space associated with specific research findings. This permits the adaptation and refinement of BMPs according to local conditions. In the "flat world" described by Friedman (2005), the global plant nutrient industry could be connected to the global plant nutrition science … in real time. A common framework should facilitate that connectivity.

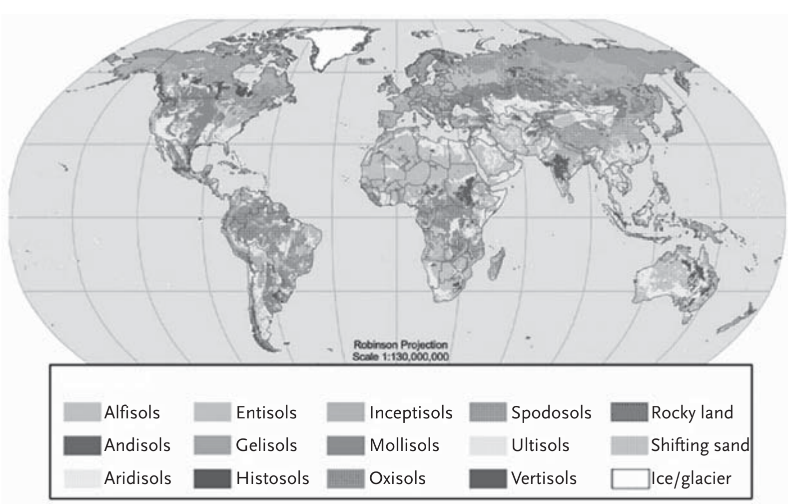

Figure 5. Global soil regions.

- **A universal educational (and marketing) tool**. A framework accepted around the world would justify significant investment in state-of-the-art and state-of-the-science educational tools based on that framework and a mechanism for maintaining them. An educational focus on the fundamental principles involved in defining site- and grower-specific BMPs would be akin to teaching a hungry person to fish rather than simply offering a fish. Improving the expertise required to adapt BMPs to local circumstances rather than attempting to teach generalized BMPs may have a more positive impact on nutrient management. The recent extension of electronic technologies such as cell phones to nearly every corner of the globe has opened the door for sweeping impacts of such educational tools. This same framework should be useful in the marketing efforts for specific products or services, by showing how the specific item fits into the generally accepted principles leading to BMPs.

The fertilizer industry's success at promoting greater implementation of fertilizer BMPs may greatly influence how rapidly and to what extent the newly redefined potential of agriculture is realized. Impacting that success will be whether sufficient value is recognized in localized intensive management to generate profit margins sufficient to cover its true costs.

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Fertilizer Best Management Practices
First edition, IFA, Paris, France, August 2007

ISBN 2-9523139-2-X

The publication can be downloaded from IFA's web site.
To obtain paper copies, contact IFA.

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