GLOBAL FERTILIZER TRENDS - GETTING MORE INTO YOUR CROP?

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Fertilizer continues to play an essential role in supporting production of food, feed, fiber, and fuel. It has been estimated by various sources that at least half of the worlds food supply is dependent on fertilizer inputs (Erisman et al., 2008; Stewart et al., 2005). The appropriate use of plant nutrients relies on careful management and stewardship. Much of the fertilizer industry has adopted the principles of 4R Nutrient Stewardship for guiding fertilizer use decisions. 4R management refers to using the Right Source of nutrient, at the Right Rate, applied at the Right Time, and put in the Right Place. When these four factors are appropriately considered for local cropping conditions, the economic, social, and environmental impacts are properly considered.

Plant nutrients are a globally traded commodity and their production and marketing are influenced by numerous factors with international ramifications. For example, currently low overall crop prices and large global cereal stocks are a disincentive to farmers to fertilize for maximum yield. This occurs despite the fact that achieving maximum economic yields should prompt farmers to maximize production while increasing efficiency. This is almost impossible to accomplish when growing nutrient-deficient crops.

Global policy developments also have a large impact on global fertilizer use and pricing. For example, China adopted a "zero-growth" policy for fertilizer in 2015 that caps fertilizer use by 2020. They also added a 13% tax on fertilizer sales and exports. The Chinese government decision to end its maize stockpiling policy also causes a shift to more soybean production and a lower domestic fertilizer demand.

In India, the fertilizer subsidy regime continues to heavily support low farm prices for N fertilizer, but not for P and K. This subsidy frequently leads to over-fertilization with N, and imbalanced consumption of other deficient nutrients.

The N industry is forecast to invest over $100 billion in new production facilities, centered in North America, West Asia, and the Russian region. This rapid expansion may lead to a temporary surplus in N fertilizer.

Global production of P fertilizer is expected to grow in the next five years, with the increased capacity coming from Morocco, a new mine in Saudi Arabia, and from China. The capacity to produce potash fertilizer is also rapidly expanding, due to new or improved mining facilities in Canada, Russia, and other nations. Sulfur fertilizer is primarily produced during its removal from fossil fuels (petroleum products and natural gas). Sulfur is expected to be in plentiful supply for at least the next five years.

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Global fertilizer trade map, 2016 (ICIS and IFA, www.fertilizer.org/GlobalFertilizerTradeMap)

IMPLEMENTING 4R NUTRIENT STEWARDSHIP

The four "rights" provide a simple framework to assess whether a given crop has been fertilized properly. Asking "Was the crop given the right source of nutrients at the right rate, time, and place?" helps farmers and advisers to identify opportunities for improvement in fertilizing each specific crop in each specific field.

A balance of effort among the four rights is appropriate. It helps avoid too much emphasis on one at the expense of overlooking the others. Rate may sometimes be overemphasized, owing to its simplicity and direct relation to cost. Source, time, and place are more frequently overlooked and may hold more opportunity for improving nutrient performance.

The four "rights" are interconnected. They must work together and with the surrounding environment of plant, soil, climate, and management. For most farms where plants are managed to provide food, feed, fiber, fuel, and aesthetic benefits, soils are the medium in which the plants grow. Soil fertility is a basic need for plants to grow productively. Although fertility is vital to productivity, not all fertile soils are productive soils. Poor drainage, drought, salinity, insects, diseases, and other factors can limit productivity, even when fertility levels of all plant nutrients are adequate. To fully understand soil fertility, we must consider all the factors which support or limit crop productivity.

RIGHT SOURCE: Provide a balance of all essential plant nutrients, considering the use of every available nutrient source. Plant roots only take up nutrients in a soluble form and they must be present when the plant needs them. Phosphorus fertilizer sources should be selected based on plant availability, chemical properties, and need for other nutrients. Potassium fertilizer sources should be selected based on their chemical and physical properties, and the crop nutrient requirement.

RIGHT RATE: Add fertilizer based on the soil nutrient supply and the plant demand. Application rates should be adjusted based on regular soil testing to account for the existing

nutrient supply. Realistic predictions of crop performance and yield can be used to estimate crop requirements and nutrient removal. Potash application rates will also account for fertilizer use efficiency. Apply P based on soil nutrient supply and plant demand. Have the soil tested to determine the risk of P deficiency, and whether replenishment of removal is needed. Realistic predictions of crop performance and yield can be used to estimate crop nutrient removal.

RIGHT TIME: Decisions on the time of fertilizer application should account for the dynamics of crop nutrient demand, soil nutrient supply, potential losses, and the logistics of field operations. In general, it is preferable to add fertilizer as close to the time of plant uptake as possible. For alfalfa, it is often best to preload the soil with an adequate nutrient supply prior to planting. Risk of water contamination can be much higher when P is applied during periods of higher likelihood of surface runoff and active tile drain flow. Decisions on the time of potash application should account for the nutrient demands of the crop, the soil nutrient supply, potential losses, and the ability to get application equipment into the field. In general, it is preferable to add fertilizer as close to the time of plant uptake as possible. However for p and K fertilizer, application often precedes crop uptake by months because the risk of loss to the environment is low.

RIGHT PLACE: Plant nutrients need to be in a soluble form before roots can acquire them. Potassium fertilizers are generally soluble, but they do not move far in the soil before the K is held on charged sites of clay minerals. Fertilizer K can be applied to the soil surface and then incorporated by rainfall, irrigation, or tillage, or it can be added in concentrated zones beneath the surface to maximize plant recovery. The concept of “right place” also refers to applying fertilizer only in field zones where crops will positively respond to nutrient additions. In consistently low-yielding areas, it may be useful to reduce fertilizer applications to match crop needs, avoiding the risks of inefficiency and economic loss. Consider where plant roots are growing, and how soil is reacting with applied nutrient sources.

There is growing awareness of the important of boosting nutrient efficiency in all cropping systems. Here are some general principles that are useful to consider when making a nutrient plan that considers the 4R strategies (Johnston and Bruulsema, 2006):

1. Measure what the soil can provide. Soils may contain rich reserves of nutrients. Test once every 2 to 3 years for stable nutrients like phosphorus (P) and potassium (K). For mobile nutrients like nitrogen (N), test for each crop, but at just the right time. For example with corn, soil nitrate tests most meanigful if the sample is taken “pre-sidedress”, when the corn is 6 to 12 in. tall. Be sure you understand whether your soil test lab is including any N credits from previous legume crops. As current UC Davis research indicates, the N contribution from prior alfalfa crops can be considerable.

2. Consider crop removal. Do you know how much P and K the last crop took out of the soil? You can estimate it if you know yield levels. Unless soils contain so much that you don’t worry about depleting fertility, what was removed should likely be replaced. A healthy crop of alfalfa can 15 lb P_2O_5/ton and 60 lb K_2O/ton of hay.

3. Set realistic yield goals. Applying adequate (but not excessive) nutrients to meet the target yield is critical to optimizing fertilizer efficiency. However, over- or under-application will result

in reduced nutrient use efficiency or lost yield or crop quality. Be sure yield goals reflect past production history, appropriate for each field.

4. Use all nutrient sources available. Using manures in a manner to minimize nutrient losses can be challenging. Proper manure storage should help protect against those losses. Manure application shouldn't get in the way of timely planting. Manures and other organic materials should be directed to the soils that need the organic matter most. Analyzing manure in the laboratory helps refine nutrient credits to ensure that fertilizers appropriately supplement what is applied.

5. Keep the proper balance of nutrients. When fertilizer prices rise, it is common to see growers reduce the application of all nutrients except N. For a soil with adequate supplies of P, K, and S, this can work in your favor. However, if soil is low in any of these nutrients, it may be better to lower the rates of all those required to optimize crop yield and quality.

6. Manage soil pH. Liming acid soils produces many benefits. Among these benefits are more effective N_2 fixation in legumes, and better availability and more efficient use of P and K.

7. Manage crops for maximum economic yield. Anything that limits yield usually limits nutrient use efficiency. Choosing the right genetics, seeding rate, planting at the right time, and managing soils for physical properties are all important. Ensuring that all field operations get done on time requires a lot of attention to logistics, but pays off with a better ratio of nutrients harvested versus applied.

8. Controlled-release fertilizers. You may not always be able to apply fertilizer just before plant uptake. "Just after" the crop demand is too late. Many useful products that delay conversion of N sources to nitrate have entered the market. These include inhibitors of urease or nitrification, or coatings that slow the release of urea into solution. The key is to find a product that releases N in the root zone just before the plant needs it.

10. Place the fertilizer in the right place. Phosphorus is particularly effective at invigorating young seedlings when it is placed in a band close to the seed. The starter band should include N and K as well if they are required. Higher rates need to be moved further from the seed to avoid damage from salt or ammonia.

11. Do your own on-farm testing. Recommendations are only as good as the research relating to crop response. For important nutrient questions that your local recommendations can't answer, replicated strip trials on your own farm may be the best solution.

12. Consult a credible adviser. Managing nutrients is complex and site-specific. Certified Crop Advisers (CCAs) know how to balance crop nutrients and also provide the many pieces of advice that farmers require. Every farm and field is different, so it is important to select the best management practices suited to field conditions. Efficiency has many facets. Nutrient management is more than applying the minimum to get an average crop. It needs to consider how the productivity of a cropping system is going to be maintained over the long-term.

The 4R Nutrient Stewardship Framework provides a comprehensive approach for managing plant nutrients to increase food production while improving the ecological integrity of farms. When correct decisions are made regarding the 4R's, there are many benefits, including better crop growth, decreased nutrient leakage to the environment, and the protection of natural areas and wildlife.

Implementing 4R principles is challenging because there is no single set of correct practices that can be universally adopted. Each farmer and crop adviser makes decisions best suited to local conditions and crops—adjusting practices for each field and soil, production targets, weather conditions, economic objectives, water quality concerns, and regulations—to meet the overall goals. Because local conditions determine the appropriate 4R practices, nutrient management decisions are best made at a local level, rather than with centralized regulations.

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