

4R NUTRIENT STEWARDSHIP

Adapted from "The Efficient Fertilizer Use Manual",

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4R Nutrient Stewardship promotes using the right fertilizer source, at the right rate, at the right time, and in the right place. Following the 4Rs can help increase yields and profitability while protecting the environment and improving sustainability. Your crops will thrive from receiving proper nutrition more efficiently.

FERTILIZER USE AND THE 4RS

Fertilizers are a necessary component of sustainable crop production. When properly managed, fertilizers help address the challenge of increasing production in an economically viable way while retaining the ecological integrity of cropping systems. However, if nutrients are not adequately available within a crop production system, fertility is mined from the soil, and the crop will never attain optimal yields.

Conversely, if nutrients are supplied in excess or without managing risks, the possibility of nutrient movement away from the cropping system increases, potentially negatively affecting the environment. In both situations, the profitability of the cropping system will be negatively impacted by lost yield or by lost inputs.

4R Nutrient Stewardship utilizes fertilizer best management practices (BMP) addressing the right fertilizer source, at the right rate, the right time, and in the right place. The 4Rs provide the foundation for a science-based framework to achieve sustainable plant nutrition management. In short, 4R practices are good for the grower, good for the farming community, and good for the environment.

There is an existing need to improve the adoption of fertilizer best management practices to enhance the sustainability, efficiency and productivity of agricultural systems. Efficiency and productivity together are interwoven with sustainability. Striving to improve efficiency without also increasing productivity simply increases the pressure to produce more on lands less suited to agricultural production.

Conversely, squandering resources to maximize productivity can result in increased environmental impacts and decreased profitability.

The essential plant nutrients play a vital role in providing adequate food supplies and protecting our environment.

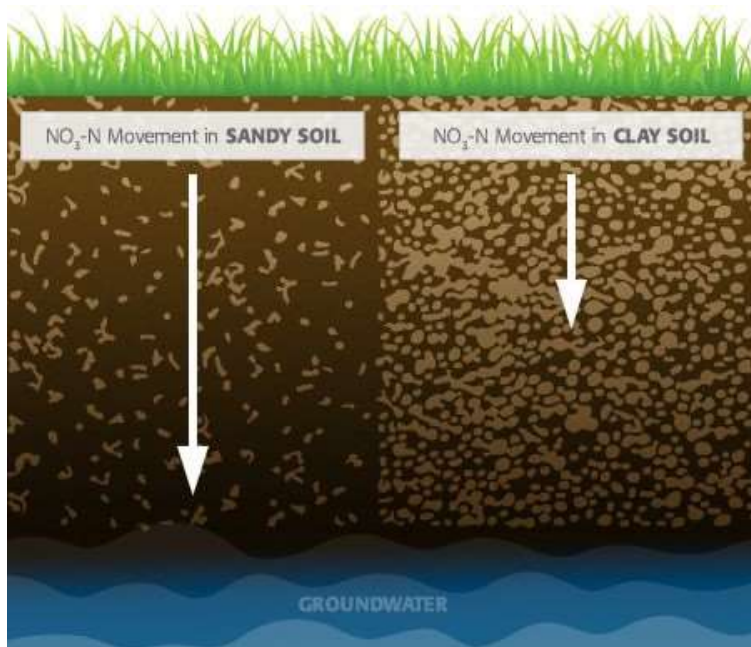
Plant nutrients promote a more vigorous, healthy and productive crop. A vigorously growing crop has greater root systems, more above-ground residue, sustained green top growth, quicker ground cover, greater water use efficiency, greater nutrient efficiency and higher resistance to crop stresses caused by drought, pests, cold temperatures or delayed planting. Plant growth through the process of photosynthesis utilizes atmospheric carbon dioxide, a greenhouse gas, and generates life-sustaining oxygen. While many nutrients are essential to plant health, some nutrients pose a greater environmental risk than others when improperly managed. The two nutrients most often associated with mismanagement and non-point-source environmental concerns are nitrogen (N) and phosphorus (P).

NITROGEN AND THE ENVIRONMENT

When soil nitrogen supply becomes low, plant stresses are immediate and yield losses are assured. The large demand crops have for nitrogen (legumes are an exception) means that supplemental sources must be provided for efficient and sustainable crop production. All these sources, when added to soils enter the nitrogen transformation cycle and are eventually converted to plant-available ammonium and nitrate-nitrogen. To meet crop management objectives, fertilizer best management practices must ensure that adequate amounts of nitrogen are used for profitable production levels, while minimizing any potential negative effects on the environment. This is best achieved by utilizing practices that address the 4Rs.

Much of the concern about nitrogen in the environment is due to the potential movement of unused or excess nitrate-N through the soil profile into groundwater (leaching). Because of its negative charge, nitrate-nitrogen is not attracted to the various soil fractions. Rather, it is free to leach as water moves through the soil profile. Soil type has an influence on the amount of and speed with which nitrate-nitrogen moves through a soil profile, with movement greater in sandy as compared to clay soils.

Nitrogen loss as ammonia volatilization from surface-applied sources and as dinitrogen gas (N_2) or nitrous oxide (N_2O) from soil microbial activity is also a concern.



Nitrate is more likely to move downward in sandy soil than in clay soil. Source: IPNI

PHOSPHORUS AND THE ENVIRONMENT

Phosphorus has been associated with environmental pollution through the eutrophication of lakes, bays and non-flowing water bodies. The symptoms are algal blooms, heavy growth of aquatic plants and deoxygenation. Since phosphorus is insoluble relative to other essential nutrients, environmental degradation is associated largely with phosphorus movement when soil erosion occurs. Except on some organic soils, very low concentrations of phosphorus are found in drainage waters as the result of leaching. The major form of phosphorus entering surface waters in most agricultural watersheds is particulate-phosphorus associated with either clay soil fractions or organic matter. These fractions are the most easily

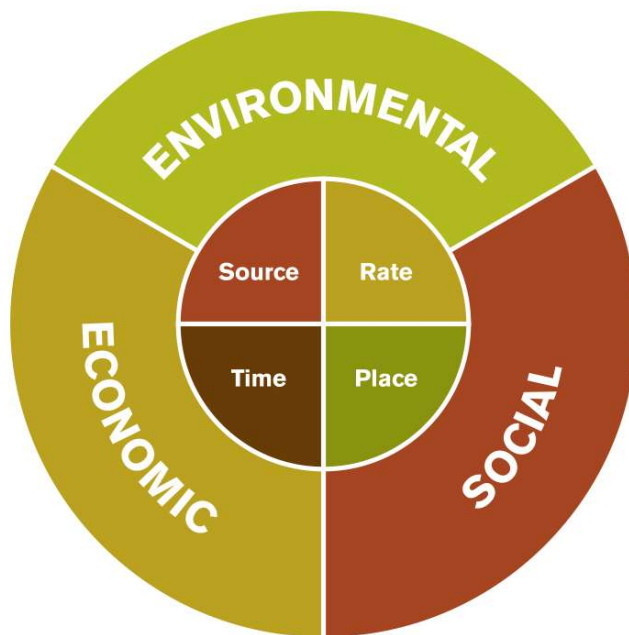
eroded, and have a relatively high surface area that contains enriched phosphorus levels compared to soil particles that have greater resistance to erosion.

Sediment-enriched phosphorus commonly contains two to six times that of soil phosphorus levels that are left behind. High-loading in surface runoff is usually associated with storm events. Storm flow concentrations of soluble phosphorus are often 10 times greater than base flow concentrations.

Numerous research studies have shown that conservation tillage practices reduce soil erosion and the movement of phosphorus from agricultural lands. Conservation tillage is a BMP because it reduces erosion considerably by absorbing the impact of falling rain and slowing water runoff. If erosion is stopped, then phosphorus losses to the environment will be reduced to acceptable minimum levels.

4R IMPLEMENTATION FOR SUSTAINABLE CROPPING SYSTEMS

Production demands, input requirements and environmental impacts taken together mean the risks for making the wrong nutrient use decisions is greater now than ever. When fertilizer BMPs result in increased production and input use efficiency, they also reduce losses to the environment. When making practice selection, the interconnectivity between practices addressing source, rate, time and place should be considered.



While the scientific practices governing the 4Rs are universal, practice implementation is site-specific; so there is not a common management plan or set of practices that will work for everyone in every location. Crop advisors are key in the efforts to increase adoption of 4R Nutrient Stewardship with growers.

Selecting BMPs for increasing nutrient efficiency and productivity while reducing environmental impact begins with addressing the scientific principles behind the 4Rs. Fertilizer BMPs should be selected based on these principles, and should then be used in combination with other conservation practices.

RIGHT SOURCE:

Ensure a balanced supply of essential nutrients, considering both naturally available sources and the characteristics of specific products in plant-available forms. Specifically, consider nutrient supply in plant-available forms, ensure the nutrient suits soil properties, and recognize the synergisms among elements.

RIGHT RATE:

Assess and make decisions based on soil nutrient supply and plant demand. Specifically, appropriately assess soil nutrient supply (including from organic sources and existing soil levels), assess plant demand, and predict fertilizer use efficiency.

RIGHT TIME:

Assess and make decisions based on the dynamics of crop uptake, soil supply, nutrient loss risks and field operation logistics. Specifically, assess the timing of crop uptake, assess the dynamics of the soil's nutrient supply, recognize weather factors, and consider logistics.

RIGHT PLACE:

Address root-soil dynamics and nutrient movement, and manage spatial variability within the field to meet site-specific crop needs and limit potential losses from the field. Specifically, recognize root/soil dynamics, manage spatial variability issues, consider the tillage system, and limit potential off-field transport.

FERTILIZER BEST MANAGEMENT PRACTICES THAT ADDRESS THE 4RS

YIELD LEVEL

Use historical records and yield monitors to set realistic yield goals, which are at least 5 to 25 percent above average. Review the current management of agronomic factors used in growing each crop.

Optimum yield levels are the result of using a package of all proven BMPs for agronomic factors such as variety selection, plant population, row spacing, planting date, tillage practices, balanced fertilization and pest control. New yield-monitoring devices being used in conjunction with precision agriculture are useful in developing a more reliable and accurate yield history. Site-specific (within field) management can then be used to make adjustments in field variations and to improve overall yield and nutrient efficiency.

TIMING OF APPLICATION

Avoid nitrogen applications far in advance of crop needs on coarse-textured soils. Fall nitrogen applications should be confined to fine-textured soils in drier regions, where leaching loss potential is low. Choose ammonium or ammonium-producing nitrogen sources for fall application for spring crops, and wait until soil temperatures at the 4-inch level have dropped below 50 degrees Fahrenheit.

Make sure that adequate phosphorus is available for good seedling growth. Banding phosphorus on high phosphorus-fixing soils increases efficiency.

SPLIT- OR MULTIPLE NITROGEN APPLICATIONS

Consider split-nitrogen applications according to plant growth stages and crop needs for both small grains and row crops. Preplant, starter, top-dress, side-dress and fertigation are some of the fertilizer application timing options. Plant-soil analyses can be helpful to determine additional nitrogen needs. Timeliness of application is essential to be sure crop yields do not suffer from nitrogen deficiency.

ADEQUATE & BALANCED NUTRIENT SUPPLY

Manage so that all essential nutrients are in adequate supply and balanced with nitrogen requirements. Soil testing is an essential management tool to use in helping to determine need. Crop grown, crop residues produced, and the crop rotation being used are factors to consider in determining total nutrient needs.

USE OF NITRIFICATION INHIBITOR

Nitrification inhibitors (NI) slow soil conversion of ammonium-nitrogen held by clay and organic matter to leachable nitrate-nitrogen. These compounds are especially useful on coarse-textured soils, where leaching is likely, and on fine-textured soils, where excess water can cause denitrification losses of nitrate-nitrogen. The use of a nitrification inhibitor can be helpful with both preplant and side-dressed nitrogen applications. The use of a nitrogen inhibitor can improve nitrogen use efficiency and provide crop benefits by extending ammonium-nitrogen availability and uptake.

USE OF UREASE INHIBITOR

Urease inhibitors slow the hydrolysis of urea, a reaction that produces ammonia and ammonium-nitrogen. If urea hydrolysis occurs in plant residue or on the soil surface, nitrogen losses by ammonia volatilization occur. These compounds may be effective particularly in high-residue systems.

CORRECT METHOD OF APPLICATION

Use subsurface or surface band applications of solid urea and urea-ammonium nitrate (UAN) liquid fertilizers in high-residue cropping systems to avoid nitrogen tie-up in crop residues or nitrogen loss by ammonia volatilization. Incorporate broadcast urea, UAN and manure into the soil where tillage is practiced to avoid ammonia volatilization and runoff losses.

MANURE CREDITS

Obtain a laboratory manure analysis for any available animal manures. Deduct the amount of nutrients available from total fertilizer needs. Use crop advisor estimates for the rate of nitrogen release, and subtract this nitrogen amount from total crop need.

LEGUME CREDITS

Use crop advisor's estimate of nitrogen available from a previous legume crop. While this is not a precise value, subtracting the estimated legume-nitrogen from total need helps to sharpen the supplemental nitrogen recommendations.

SOIL & TISSUE TESTING

These tests help to determine the amount of available nitrogen and phosphorus in the soil, or in the growing crop. For nitrogen, soil and tissue sampling recommendations vary by crop and by various regions of the country. Use crop advisor recommendations to determine testing methods and nitrogen credits to use.

The first step in phosphorus management is to determine the relative phosphorus status of the soil. If the soil has inadequate levels of phosphorus for optimum growth, then corrective applications must be made to raise the soil test phosphorus levels to the sufficient range. If phosphorus soil test levels are in the high range, then application rates should equal crop removal. However, soil testing alone is not the only indicator of the need for supplemental phosphorus. Placing fertilizer-phosphorus near the seeds of crops (starter) has been repeatedly demonstrated to produce increased yields and profitability, even at high-phosphorus soil tests under conditions of early planting, cold or wet soils, high amounts of residues, improper soil pH levels and the presence of soil compaction.

IRRIGATION WATER CREDITS

Analyze irrigation water for nitrate-nitrogen. An estimated amount of nitrogen that is applied via the irrigation water should be subtracted from the overall crop needs.

EROSION CONTROL

The use of conservation tillage systems in conjunction with agronomic BMPs helps to control erosion and to keep the soil and nutrients in place. Erosion control reduces the loss of all nutrients and improves nutrient efficiency and water quality.

USE OF COVER CROPS

Use of winter cover crops can help prevent nitrate-nitrogen from leaching in high-rainfall areas. Cover crops absorb residual nutrients and return them to the soil for the following crop.

Caution: There is a possible water cost with the use of cover crops in drier regions.

LIMING TO CONTROL SOIL ACIDITY

The addition of ammonium-nitrogen to the soil from commercial fertilizer, legumes, manure or sewage sludge eventually leads to increased soil acidity. The process of nitrification of ammonium-nitrogen by soil bacteria, regardless of original source of the ammonium-nitrogen, releases acidity that must be controlled by liming on soils that have a tendency to become acidic. Soil-test and maintain the recommended pH level for each field and crop. Phosphorus efficiency is dependent on maintaining soil pH in the optimum range.

When adequate and balanced fertility programs are used in conjunction with agronomic and conservation BMPs, then the optimum management steps have been taken to ensure minimal environmental impact on ground and surface waters. These are the same management steps that help ensure a plentiful food supply and farm profitability. It is fortunate that modern farming practices and environmental integrity are compatible in a world that requires more and more food each year.