**4R Principles – Do You Really Know Them?**

Tom Bruulsema, International Plant Nutrition Institute

The 4Rs are everywhere. It’s hard to find an article these days, on the topic of managing crop nutrition, that doesn’t mention 4R. That applies to scientific journal articles as much as it does to farm press and industry publications. But sometimes I wonder how deeply the full concept of 4R Nutrient Stewardship is understood.

I’ve heard many people use the term ‘principles of 4R.’ Some seem to think that as long as you’ve thought about applying the right nutrient source, at the right rate, at the right time and in the right place, it’s all done. You’ve honored all four principles. You are 4R consistent. But no, there’s more to it than that. While it comprises four components, 4R encompasses more than just four principles. In fact, IPNI’s [4R Plant Nutrition Manual](http://www.ipni.net/article/IPNI-3255) has nine chapters with several key principles in each.

The principles connect management of crop nutrition to sustainable crop production. To improve sustainability, many crop management practices beyond crop nutrition become important. That’s why we’re excited about the concept of “4R Plus” currently being implemented in Iowa. The 4Rs focus on nutrient application, which is an excellent place to start, because getting applied nutrients recovered by crops is fundamental to improving nutrient use efficiency and profitability. But nutrient stewardship goes beyond nutrient application. In fact all of agriculture can be considered the stewardship of nutrients. Soils, crops and livestock all contain large stocks of nutrients. In the end, many of the principles we apply to 4R will also need to be applied to additional practices, including those for crops, soils, and pests, extending to cover crops, tillage practices, and stream bank management. To become more sustainable, the whole cropping system needs adaptive management.

The paragraphs that follow summarize the key principles of 4R Nutrient Stewardship.

**Principles for Sustainability**

Consider stakeholder priorities. Agriculture is connected to supply chains whose stakeholders include the whole human family. Stakeholders need to have a say, choosing sustainability goals and performance metrics that reflect outcomes of management that matter to them.

Choose practices that move metrics forward. Producers choose practices through adaptive management to meet the goals and make progress toward achieving targets on key performance metrics.

Use adaptive management. Adaptive management is an ongoing process of developing improved practices for efficient production and resource conservation. This is accomplished by participatory learning and continuous systematic assessment. Adaptive management for crop nutrition evaluates outcomes of choices of source, rate, time and place combinations applied in site-specific contexts in terms of stakeholder-centric performance metrics.

Fit the 4Rs into cropping systems. Management of crops, soils, and pests, including soil conservation practices, interacts with 4R management choices and influences 4R outcomes.

**Principles for Accountability**

Consider economic, environmental and social impacts. Managing plant nutrition according to principles of 4R Nutrient Stewardship includes accountability for all three dimensions of sustainability.

Keep records. A 4R Nutrient Stewardship Plan tracks and records all crop management practices, including details on the source, rate, time and place of every nutrient application. This information is for the benefit of the manager.

Report performance. A 4R Nutrient Stewardship Plan also tracks performance, the outcome of implementing a set of practices, on all metrics of material interest to stakeholders. Sharing the data you have with trusted aggregators can improve public trust. Reporting performance information on economic, environmental, and social priorities established by stakeholders distinguishes a 4R Nutrient Stewardship plan from other nutrient man­agement plans.

**Principles for Right Source**

Consider rate, time, and place of application. The 4Rs are interlinked.

Supply nutrients in available forms. What’s applied might be in a form either immediately or slowly releasing plant-available forms of nutrients.

Suit soil physical and chemical properties. For example, nitrate is too easily lost from flooded soils, and urea on the surface of alkaline soils too easily loses ammonia.

Recognize synergisms among nutrient elements and sources. For instance, nitrogen can increase availability of applied phosphorus. Applied phosphorus can reduce availability of zinc. Fertilizers complement manures.

Recognize blend compatibility. Avoid combinations that attract moisture when mixed, and match up granule sizes when blending.

Recognize benefits and sensitivities to associated elements. For example, the chloride in muriate of potash can benefit corn, but also increases salt risk and may be detrimental to tobacco and some fruits.

Control effects of non-nutritive elements. For example, natural deposits of some phosphate rock contain non-nutritive trace elements. The level of addition of these elements should be kept within acceptable thresholds.

**Principles for Right Rate**

Consider source, time, and place of application. The 4Rs are interlinked.

Assess plant nutrient demand. The crop takes up nutrients in proportion to its yield. Yield goals are established from measured past performance, not by high hopes.

Assess soil nutrient supply. Soil testing is one method. Other options include plant analysis, on-farm omission plot trials, and crop canopy sensors.

Assess all available nutrient sources. These may include manure, composts, biosolids, crop residues, atmospheric deposition, and irrigation water, as well as commercial fertilizers.

Predict fertilizer use efficiency. Some losses are un­avoidable.

Consider soil resource impacts. If outputs exceed inputs, soil fertility declines. Whether this matters depends on current soil fertility levels.

Consider economics. The law of diminishing returns applies. For mobile nutrients like nitrogen, aim for the maximum return in the current crop, in the context of variability and uncertainty of the most economic rate. For nutrients like phosphorus and potassium, which the soil can retain, maintain an optimum soil test level.

**Principles for Right Time**

Consider source, rate, and place of application. The 4Rs are interlinked.

Assess timing of plant uptake. Crops take up nutrients at different rates through the growing season. Crops also have specific sensitivities to specific nutrient shortages at different times.

Assess dynamics of soil nutrient supply. As soil warms up through the growing season, available nutrients mineralized from organic matter can accumulate.

Recognize dynamics of soil nutrient loss. Rains exceed soil water storage capacity most often in late fall and early spring, so runoff risks can be higher.

Evaluate logistics of field operations. Nutrient applications that delay timely planting are counter-productive, and the soil compaction effects of applications at different times need to be considered.

**Principles for Right Place**

Consider source, rate, and time of application. The 4Rs are interlinked.

Consider where plant roots are growing. Nutrients need to be placed where they can be taken up by growing roots when needed.

Consider soil chemical reactions. Concentrating soil-retained nutrients like phosphorus in bands or smaller soil volumes can improve availability.

Suit the goals of the tillage system. Subsurface place­ment techniques that maintain crop residue cover on the soil can help conserve nutrients and water.

Manage spatial variability. Assess differences within and among fields in crop productivity, soil nutrient supply capacity, and vulnerability to nutrient loss.

**Conclusion**

The importance of these principles of 4R Nutrient Stewardship is that they have been carefully selected for consistency with the sciences of soil fertility and plant nutrition, and with global standards for sustainability verification. This consistency is important for the extensive collaboration that is essential to improving sustainability and to communicating those improvements to the wide range of stakeholders involved. The 4R path is the one most likely to harmonize profitable agronomics at the field scale with improved sustainability of the agricultural system as a whole. The 4R principles make a difference to our industry’s ability to participate with sustainability organizations like Field to Market®.

**Take-home**

4R has more than four principles. Selection of the right four components for nutrient application is governed by scientific principles for economic, environmental, and social success. It’s important for your growers to understand that 4R is the framework for the collaboration that is essential to improving agricultural sustainability.