4R Nutrient Stewardship: Basics

This document is in accompaniment to the 4R Nutrient Stewardship: Basics presentation. Included are notes for each slide to help educators present the material to their classroom.

Introducing 4R Nutrient Stewardship Across Canada

Nutrients For Life
Nutriments pour la vie

Introductory slide

Welcome to the 4R Nutrient Stewardship Basics presentation prepared by Nutrients For Life Canada. The purpose of this presentation is to act as a teacher resource for students to compliment our 4R Case Study 1: An introduction to 4R Nutrient Stewardship. Over the next few slides participants will learn the basics of 4R Nutrient Stewardship and how it applies in Canada, and we will delve into discussions surrounding the benefits of 4R Nutrient Stewardship with current examples. Please sit back and enjoy the presentation.

Slide two

Before we get started on learning about 4R Nutrient Stewardship, first, please let me introduce you to Fritz Haber. Fritz was the first scientist, a German Chemist actually to discover the process for making ammonia from atmospheric nitrogen more than 100 years ago, he solved a huge challenge that limited crop yields in the early 1900's.

Now known as the Haber–Bosch process, this discovery paved the way to make cheap commercial production of nitrogen and phosphorous fertilizers possible, resulting in higher crop yields, continuous cropping systems, and the use of high yielding varieties, and all the technologies that promoted the green revolution.

We now know that putting too much fertilizer on the soil is economically and environmentally unwise. Not only can it contaminate surface and ground water, nitrogen fertilizer also reacts in the soil, increasing soil emissions of the greenhouse gas nitrous oxide and increased greenhouse gas emissions from human activity have led to climate change.

This presentation will serve as an introduction to 4R Nutrient Stewardship in efforts to help you to understand the economic, social and environmental benefits of putting these beneficial practices to work on farms in your area, and also to give students and teachers a bit of background about 4R Nutrient Stewardship.

Slide three

But enough about Haber, let's talk about sustainability. Sustainability can be a complex issue so let's start with the simple idea of an increasing human population relying on the world's finite set of resources.

With this enormous increase in global population and more specifically a dramatic increase in the middle class, there is going to be demand not only for more food but also for better quality food globally. So food production will need to expand both in quantity and quality over the next 40 years. What's more, this increase will need to come almost entirely from our existing land-base.
The question is, how do we sustainably feed 9 billion people? And that's where 4R Nutrient Stewardship will play a key role in meeting this sustainability challenge.

Slide four

So let's explore this sustainability challenge a little further. The Food and Agriculture Organization (FAO) of the United Nations forecasts that production will need to increase by at least 70% per cent to ensure food security by the year 2050.

Global food security requires agricultural systems to change in the direction of higher productivity. Of course, higher productivity, if not done with sustainability in mind, tends to increase greenhouse gas emissions. It can also lead to a whole other set of problems, increased soil erosion and soil acidification, phosphorus or nitrogen pollution of surface waters and ground waters and reduced water quality. So while we need to intensify crop production we need to do it as intelligently and as sustainably as possible.

So there is the challenge, more people, more food, no new land, and reduced impact on the environment particularly lower greenhouse gas emissions. Meeting this challenge is not the job of farmers alone. It will require a strong commitment by the entire human community to the development and deployment of ecologically friendly food productions systems.

Producers will require more than just new technologies; they will require a new framework that spells out the principles and practices of sustainable agriculture. With respect to crop production, the 4R Nutrient Stewardship Program has been designed for just this purpose.

The aim of 4R is to improve nutrient management on the farm. In fact it's designed to improve nutrient management on a field-by-field basis. But before we get to that let's start by taking a big picture look at 4R Nutrient Stewardship.

Slide five

4R nutrient stewardship is one of the cornerstones of our sustainability program and it gives farmers the ability to use Best Management Practices for the efficient use of fertilizer.
The 4R Nutrient Stewardship Program spells out the principles and practices of sustainable agriculture.

Sustainability can ONLY be achieved by balancing the economic, social and environmental goals. Too often, sustainability is defined as "environmental" only. It is essential that we start with the economics on the farm – it needs to be profitable – but let's not also forget about the social aspect and ensuring that it meets society's needs.

Fertilizer Canada has been working with federal and provincial governments as well as farm groups to promote the adoption of the Right Source @ Right Rate, Right Time, Right Place®.

This presentation is about making those Right Source @ the Right Rate, Right Time, Right Place decisions. With regards to 4R Nutrient Stewardship there is no one magic formula or no one answer that can be applied across all farms and all situations. It's a sustainable agriculture framework based on soil physical, chemical, and biological characterization where site specific farm information allows users to work most effectively at minimizing environmental concerns while maximizing profits and yields.

Terry Roberts, the president of the International Plant Nutrition Institute and one of the brains behind 4R Nutrient Stewardship perhaps says it best. To quote Terry .. " the concept of 4R is simple – apply the right source of nutrient at the right rate, at the right time and in the right place – but the implementation is knowledge intensive and site specific". So while the principles behind 4R are universal and can be applied to any cropping system, the practices need to be adapted to the specific conditions of the cropping system. Hopefully this presentation will give you some of the tools you need to start that process of applying 4R principles and managing nutrients on a site specific basis.

Okay so what do the 4R's stand for again? Can you name all four?
Example:
Right Source - What is the best source to obtain balanced fertilization?
Right Rate - How much fertilizer do I need to to apply on my farm?
Right Time – What is the optimum time to apply nutrients (spring or fall)?
Right Place – Where is the best place to put the nutrients?

Teacher Activity
Under three headings: Economic, Social, and Environmental – please ask students to add aspects of what they think might apply towards these sustainability pillars. There are no right or wrong answers. Please keep record of this for later in the lesson.

Slide six

So what does sustainable agricultural goals look like? Starting with economics, one national goal is to maintain farms as being financially applicable.

Student Activity
Show students slide – after 10 seconds remove the slide and then ask students to create three groups on the board (Environmental, Economic, and Social) and ask students then to add bullets to the sustainability goals on their reasoning behind sustainability goals.

What did they have? Discuss the differences between the groups.

Slide seven

If we are going to ensure crops are adequately supplied with nutrients first we need to know what nutrients are required by crops. Before we start listing off nutrients maybe we should answer the question what is a plant nutrient?

Unlike us plants can manufacture everything they need from elemental forms. A plant nutrient is an element that is required by a plant to complete its lifecycle. All plants need 17 of these essential elements. The first three essential elements are Carbon, Hydrogen, and Oxygen. These three elements are the basic building blocks of carbohydrates which in turn are used to form all the different components in the plant. Plants get their carbon from the carbon dioxide in the atmosphere and their hydrogen and oxygen, or at least the hydrogen and oxygen they use to build more complex molecules, from water. Like us plants also use oxygen from the air during respiration. The remaining 14 essential elements are taken up from the soil and because they are soil supplied they are often referred to as the mineral nutrients.

In this course when we are talking about "nutrients" we are talking about these 14 mineral nutrients that crops get from soil. The 14 are often broken down in two subsets. The first group of six - Nitrogen, Potassium, Phosphorous, Calcium, Magnesium, and Sulphur are called the macronutrients because they are required in relatively large amounts. The remaining eight are required in quite small amounts and are referred to as the Micronutrients. They include Iron, Copper, Chloride, Boron, Manganese, Molybdenum, Nickel, and Zinc. Just to give you an idea of the relative quantities required, a typical plant requires 1 atom of Nickel for every million atoms of nitrogen.

Quite a difference but this brings us to the most important concept in plant nutrition. It's called Liebig's law of the minimum after the scientist who figured out in the late 1800's. And what exactly did Liebig figure out …………he figured out that plant growth is limited by the nutrient in shortest supply. In other words, regardless of whether the nutrient is required in large quantities like nitrogen or miniscule quantities like nickel, if the plant does not have a sufficient supply, the growth of the plant will be limited by that least available nutrient.

So quick review, plants can build everything they need from 17 "essential elements", we refer to the 14 elements taken up from the soil as mineral nutrients or in this course just nutrients. Plants use nutrients as building blocks but they can only take them out of the soil in particular forms, Let's take a look at these plant uptake forms next but before we do I want to leave you with a thought on balanced nutrition. If you think about it balanced nutrition means that the crop has a sufficient quantity of all required nutrients to meet the yield goal or yield potential of the site.

Take out manure spready and put in liebigs barrel

Slide eight

What other factors affect nutrient uptake and loss in your crops? Well we have a number of them starting with weather, identified through moisture and temperature; in addition to the physical and chemical properties of soil tlike soil texture, aeration, soil pH, organic matter, and Cation Exchange Capacity (CEC); and the use of Best Management Practices(BMPs) of the 4Rs namely Right Source @ Right Rate, Right Time, and Right Place in your site specific situation.

Weather more specifically has a large impact on 4R production decisions and its especially important for PEI farmers to review local weather conditions as a resource to help them with this over the long term. Depending upon the type of fertilizer and method of application, losses can occur if conditions are not suitable for application. farmers need to gauge their starting dates related to understanding local temperatures, moisture, soil conditions and the number of days required for application. For fall applications of anhydrous ammonia, applications should wait until soils cool to 10oC. Its also great to keep a record from year to year of your local conditions for future management decisions.

Slide nine

This section is about making those Right Source @ the Right Rate, Right Time, Right Place decisions .It is important to note that with 4R Nutrient Stewardship, there is no one magic formula or one answer that can be applied across all farms and all situations.

Terry Roberts, the president of the International Plant Nutrition Institute and one of the brains behind 4R, perhaps says it best. To quote Terry .. " the concept of 4R is simple – apply the right source of nutrient at the right rate, at the right time and in the right place – but the implementation is knowledge intensive and site specific". So while the principles behind 4R are universal and can be applied to any cropping system the practices need to be adapted to the specific conditions of the cropping system. Hopefully this course will give you some of the tools you need to start that process of applying 4R principles and managing nutrients on a site specific basis.

Slide 10

What are some ways we can use 4R strategies to limit Phosphorous losses to surface water? Research suggests that accurate soil testing can provide a pretty decent indicator of the risk of dissolved P loss as well as being a useful tool for establishing the right rate for various crops. In short, soil tests prevent over-fertilization and help to reduce P loadings into our rivers and lakes.

BMP number 2….it Minimizes erosion to limit particulate P losses. Use incorporation/banding to place fertilizers below the surface reducing the risk of P entering surface water from runoff. Establish buffer strips to catch and use N & P from spring and summer rainfall.

Nitrates in runoff can be taken up by riparian vegetation roots. The higher the organic matter in the soil the better the absorption. The plants then use nutrients in surface water runoff for growth. The use of buffers in riparian zones is also beneficial for the transformation of organic and inorganic compounds through exposure to extreme temperatures, sunlight, or dry conditions. For example agricultural chemicals can be converted to less toxic compounds like glyphosate (Roundup) can be converted to carbon dioxide and water. As a disclaimer here, please take my word for it and don't try this one at home. Another benefit is phosphates and ammonium can stick to the clay particles in riparian zone soils thereby absorbing much of the nutrients. Remember PEI has specific Provincial setbacks for buffer zones width requirements with regards to crop production and livestock production. More will be discussed in Section 3 regarding this legislation. BMP number 3………placing P fertilizers or manure below the surface reduces the interaction of added P with runoff water and lowers the risk of P entering surface water from runoff.

Timing combined with P placement is also an effective strategy for both increasing P availability and uptake and preventing loss in annual crop systems. In our cool springs, seed placing P or side-banding are far more effective practices for getting P to the crop when it needs it than banding away from the seed or broadcasting. Also placement near or with the seed, means the application occurs after the high risk spring runoff period.

Finally, establishing buffer strips along waterways can help catch and use P from spring and summer rainfall. Keep in mind however, that buffer strips may be of limited use in preventing P loss during spring runoff. Recent research suggests that buffer strips are not always effective when runoff is moving over frozen ground and the vegetation not growing.

Slide 11

Here is a quick summary of our phosphorus discussions. Under Right Source remember that most of the P sources are in highly soluble form when they are applied, they all convert to orthophosphate and then they precipitate. Some of the new controlled release products may slow this process but for the most part tie up in the soil is inevitable. Remember too that, adsorbed and precipitated P creates the soils capacity to recharge the soil solution P that plants feed on over the course of the growing season.

For Rate of P…rate should match crop nutrient requirements. The BMP to achieve this is based on soil test recommendations and fertility guidelines.

For Timing of P…timing should coincide with periods of greatest demand or lowest risk of environmental loss and the BMP to achieve this is to apply in spring at or near the time of seeding to meet early growth demands of young plants.

For Placement of P….P should be placed where it is easily accessible when required….The BMP to achieve this is placing it in the soil or with the seed depending on crop sensitivity.

And under general land management it is suggested to grow high yielding high input crops on productive lands and use BMP’s that adjust P fertilization practices for any limitations related to growing conditions and land capability.

And remember this is just for phosphorous, a similar example is also available for nitrogen! Next let’s delve into Adaptive Management. Who know what that means?

Slide 12

The 4R program has roots in adaptive management and continuous improvement. The theory of adaptive management is pretty simple. In a nutshell, you think up ways to improve the system, you implement them, you assess the impact and if it provides significant benefit it becomes part of the system and you move on to the next round of improvements. If the benefit is marginal or the impact is negative, then it's back to the drawing board and try something else. I bet that you are already following a process something like that on your farm. What a 4R plan does for you is provide some guidance through those key scientific principles in developing or changing new practices. It also encourages you to keep track of what you are doing closely and measure the results of change positive or negative.

You probably noticed that this adaptive approach is somewhat cyclical in nature. When we talk about it in relation to 4R planning we can think of it as the 4R planning cycle. We've represented it here as a 5 step process that involves goal setting, assessing production information, formulating a plan, implementing practice change and monitoring effectiveness. This brings us back to the start of our cycle where we will revisit our goals to make sure they are still relevant and then implement any adjustments to our practices.

Slide 13

So far we've talked about some of the basic principles of 4R Nutrient Stewardship, but what's the real big idea in using them?

Crop producers are part of the problem but they are also a major part of the solution. That's not to say that farmers have got it all wrong. In fact, many farmers are already practicing sustainable agriculture and 4R Nutrient Stewardship can provide a framework for them to continue to improve their operations. That's where the Farming 4R Island comes into the picture. Farmers who incorporate Farming 4R Island planning into their operations will create benefits both on and off the farm.

To start with improved nutrient management results in increased nutrient use efficiency and generally increased return on dollars spent on nutrients. This also leads to a win in the environmental column as improved nutrient use efficiency reduces the risk to nutrient loss and reducing Phosphorus and Nitrogen losses to surface waters in the watershed basin which will over time help improve water quality.

Using the 4R Nutrient Stewardship program to document nutrient management practices it will assist farmers in tracking progress and making improvements and adjustments in future years.

It will also provide records that will be useful in demonstrating environmental stewardship and compliance. In the future, having a 4R Plan will also be useful in accessing markets that may require documentation of sustainability.

Slide 14

Give students sticky notes and ask them to work as teams to identify challenges that we face in feeding the world?

Review the answers. Next ask for the solutions.

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For more 4R Nutrient Stewardship resources
or information, please visit:

nutrientsforlife.ca