

4R NUTRIENT STEWARDSHIP: LESSON ONE, TEACHER AID

This course introduces students to agricultural sustainability through the implementation of 4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, and Right Place®).

*INTRODUCING 4R NUTRIENT
STEWARDSHIP ACROSS CANADA*

NUTRIENTS
FOR LIFE



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Overview

This course introduces students to agricultural sustainability through the implementation of 4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, and Right Place®). Discussions will surround how the 4R framework helps farmers maximize yields and minimize environmental impacts. This introduction to 4R Nutrient Stewardship also helps students explore modern agriculture and why sustainable practices are crucial to feeding a growing global population.

Key concepts

- Our growing world population puts increasing pressures on our current food system and agriculture;
- How to define and understand sustainable agriculture, including 4R Nutrient Stewardship;
- Understand the three pillars of sustainability – economic, social, and environmental, and;
- Learn how to apply the concept and application of the 4R framework for sustainability in agriculture.

Objectives

After completing this lesson, students will be able to

- **Define** 4R Nutrient Stewardship and its importance;
- **Identify** and distinguish between the 4Rs of Nutrient Stewardship (Right Source @ Right Rate, Right Time, and Right Place®);
- **Describe** common examples of applications of 4R Nutrient Stewardship;
- **Identify** potential sources of nutrient pollution (locally), and;
- **Recognize** the benefits of sustainable agricultural practices.

Activities

Activity 1: Introducing 4R Nutrient Stewardship.

Activity 2: Beat the Bell – a 4R Nutrient Stewardship Bell Ringer.



Activity one: Introducing 4R Nutrient Stewardship

Overview

Activity one introduces students to the concept of sustainable agriculture, specifically the principles of 4R Nutrient Stewardship. This exercise will teach students to easily identify and understand 4R Nutrient Stewardship and its applications to our current agricultural needs. Students can complete this individually or in small groups.

Materials

- Roots for Growth Video;
- Audio and video equipment;
- Teacher PowerPoint presentation - 4R Basics.

**Please note: all materials are available on our website at nutrientsforlife.ca*

Pre-activity discussion

Let's Discuss - Feeding Crops to Feed the Future

- How do you define agriculture and what does it mean to you? Imagine what comes to mind when you think of agriculture?
- Do you see an old man wearing overalls plowing the dirt with an old tractor? Or maybe you see a scientist using a satellite-based computer program to examine current climate changes, crop yields, and fertilizer applications?
- Maybe you see an agronomist testing the soil in agricultural fields developing a new plant that can absorb five (5) times its own weight in water?
- The big idea here is agriculture is ever changing. Agriculture of today is modern, fast paced, and competitive and yet requires one key element, can you guess it? Sustainability!
- Is agriculture growing towards sustainability? Let's delve into that in a bit more detail below.

Video

Roots for Growth: Watch Roots for Growth 4R Nutrient Stewardship video as a class for a real life example to help understand how 4R Nutrient Stewardship fits into sustainability and agriculture.



Activity 1 Introducing 4R Nutrient Stewardship

Teacher Resource Background Information

Today's farmers live in a world where environmental concerns and increased food demand create challenges like never seen before. But we can meet those challenges with 4R Nutrient Stewardship.

Issue/concern: According to the United Nations, the global population will increase by more than two billion people in the next 40 years, and many reports have indicated that agricultural production needs to double by 2050. Industry experts agree increased production of food, fibre, and fuel will be achieved by intensified production and not by expanded arable land base. Genetic and biotech seed industries have predicted yield increases of three to four percent per year. However, to optimize the yields of advanced seeds, fertilizer inputs must be optimized to provide the greatest potential for success.

Introduce the key concept: 4R Nutrient Stewardship Principles

The 4R Nutrient Stewardship principles are the same globally, but how they are used locally varies depending on field and site-specific characteristics such as soil, cropping systems, management techniques and climate, etc. The scientific principles of the 4R framework include:



The 4Rs work to increase production/profitability for farmers while ensuring the future of the agricultural industry

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RATE

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TIME

RIGHT
PLACE

Right Source – Ensure a balanced supply of essential nutrients, considering both naturally available sources and the characteristics of specific products, in plant available forms.

Right Rate – Assess and make decisions based on soil nutrient supply and plant demand.

Right Time – Assess and make decisions based on the dynamics of crop uptake, soil supply, nutrient loss risks, and field operation 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.



Benefits of using 4R Nutrient Stewardship

4R Nutrient Stewardship helps improve agricultural productivity:

- Optimizing nutrient management is simply good business in dealing with fluctuations in prices of fertilizers and other inputs, as well as in process of crops sold.
- Higher crop yields are well documented with better crop and soil management.
- Improved fertilizer efficiency increases the quantity produced per acre for each unit of nutrient applied, without sacrificing yield potential.

4R Nutrient Stewardship helps minimize impact to the environment:

- Adopting nutrient stewardship contributes to the preservation of natural ecosystems by growing more on less land.
- Retaining nutrients within a field's boundaries and in the crop's rooting zone greatly reduces the amount that is not utilized by plants and thereby escapes into the environment as pollution.

4R Nutrient Stewardship helps promote sustainability goals

Some commonly identified grower objectives that promote the sustainable nature of 4R nutrient stewardship include the following goals:

Economic goals

- Improve net farm income.
- Contribute to improved regional economic development.

Social goals

- Improve the quality of farm family housing, diet, and education.
- Improve productivity of farm labor by appropriate use of emerging technologies that increase efficiencies of field operations and reduce costs per unit of crop harvested.
- Improve access to sources of information to assist in farm management decision-making.



Environmental goals

- Maintain or reduce unwanted losses of nutrients to the environment:
- Reduce soil erosion of nutrient containing soil particles;
- Reduce volatile ammonia (NH₃) emissions;
- Reduce nitrification / de-nitrification losses of nitrous oxide (N₂O) and di-nitrogen (N₂).
- Reduce energy use per harvested unit of farm production.
- Improve recycling of crop nutrients from crop residues and livestock manures.

Reference: For more information please refer to the 4R Nutrient Stewardship pocket guide.

Let's discuss

1. Concept review

Review the concept of 4R Nutrient Stewardship and its definitions

Start discussing with students what are the benefits of using 4R nutrient stewardship?

2. Brainstorm ideas

Continue the discussion by asking students to form small groups to brainstorm ideas about some of the main goals of 4R Nutrient Stewardship. Ask them to write examples in a diagram on the board under the three main headings: Social, Environmental, and Economic.

NOTE: there may be some overlap between some of the examples (i.e. examples may show up in more than one heading). Another alternative would be to use post-it notes as an example and post them around the classroom in groups, then compare.

3. Activity follow-up

As a review ask students individually, or as a group, to answer the accompanying question sheet, followed by a group discussion.



Name:

Date:

4R Nutrient Stewardship Instructions

Examine the video 4R nutrient stewardship roots for growth: Feeding the World video and answer the following questions.

Video: 4R Nutrient Stewardship Roots for Growth: Feeding the World

1. What do we need to do to achieve global food security?
2. How can we meet this challenge?
3. What is the role of fertilizer in crop use?
4. What is the definition of 4R Nutrient Stewardship?
5. Why is 4R Nutrient Stewardship important now and for the future?
6. Can you name each of the 4Rs and give an example?
7. What are the benefits of using 4R Nutrient Stewardship?



Activity 2: Beat the Bell for 4R Nutrient Stewardship

A 4R Bell Ringer Teacher Instructions

Preparation

Set up 4R stations for the bell ringer and be ready with 4R activity cards. Prepare photocopies for students to record answers.

Procedure

Activity 1: Beat the bell for 4R nutrient stewardship

Tips for learning

This activity uses hands on learning combined with group interaction to quickly identify differences each of the 4Rs. After completing the exercise, open a discussion with students regarding their rationale for choosing each specific 4R.

Explain to the class that these are everyday farm management examples that farmers and agronomists need to make in order to successfully adopt 4R nutrient stewardship. It is essential that the people involved within the farm management decisions understand very quickly and identify what actions are applicable under each of the 4Rs.

Expectations

Students will:

- **Gain** a solid understanding of the importance of sustainable agriculture and how it relates to food security and the pressures of increasing population growth and associated environmental concerns.
- **Assess** very quickly with real-life farm management examples to identify which 4R it is representative of. Quick identification helps to ensure all elements are working effectively given the 4R framework.



Materials

Clock or stopwatch
Bell, whistle, or noisemaker
10 potential stations with station cards attached (photocopy)
Student Answer Sheet (photocopy)

Activity 1 Setup (prior to class) – Are you ready?

Print out station card questions for each of the ten stations. Pick locations around the classroom to represent each station and place the station card in place (could be taped on a surface along with a station number. Find a bell, noisemaker, or whistle and a stopwatch or clock. Photocopy student activity sheets for each group or for each student. You can keep a list of examples of each of the 4Rs at each station but its optional. You can also allow students to try to figure it out themselves for more advanced classes. Let's get started...

Activity 1 – Beat the Bell to 4R nutrient stewardship Teacher Instructions

Time: approximately 20 min
Students: small groups of 2-3 or to be completed individually

Activity Instructions

Read the 4R activity card at each station and accurately identify and record which 4R best characterizes the activity card example and your rationale for choosing each 4R. You have 60 seconds to answer each question. Then the bell rings. The sound signifies time is up and you need to move to the next 4R activity station. Please note that in some examples more than one 4R may apply.



4R Nutrient Stewardship Examples

Review this information with your class to ensure they fully understand the concepts.

Right Source: matches fertilizer type to crop needs.

4R Example

- Utilize nitrogen stabilizers for liquid and dry fertilizers
- Use phosphate efficiency enhancement additives to increase first season benefit of the fertilizer

Right Rate: Matches amount of fertilizer to crop needs

4R Example

- Grid soil sample all acres for variable rate application of nutrients to help determine the right rate and right placement of nutrients.
- Account for nutrient credits from the previous year to help determine the right rate
- Test irrigation water on some fields for nitrogen content and adjust application rates of fertilizer as needed.

Right Time: Make nutrients available when crops need them.

4R Example

- Utilizes split application of nitrogen; pre-season urea applications followed by liquid UAN as either a pre-plant or side-dress to assure the right rate is
- available at critical growth stages for the crop and to minimize N loss to volatilization and leaching
- Use plant tissue testing to evaluate effectiveness of the fertilizer program and as a diagnostic tool when needed.

Right Place: Keeps nutrients where crops can use them.

4R Example

- Use GPS technology to avoid skips and prevent over-application
- Deploys variable rate seeding to maximize yield while controlling input costs
- Auto steer and GPS guidance is used on all field operations and spraying applications
- Use satellite imaging to help with yield potential and fertilizer plans



Activity 2: Beat the Bell for 4R Nutrient Stewardship, a 4R Bell Ringer

4R Station Activity Cards and Answers - Teacher Resource

Station 1

A PEI potato farmer has decided to spring apply fertilizer to his Burbank potatoes rather than apply fertilizer in the fall.

Answer: Right Time, PEI potato farmer is spring applying fertilizer (Time).

Station 2

Farmer Smith decides to incorporate soil sampling, soil maps as part of his/her 4R plan for determining essential crop needs for application.

Answer: Right Rate, farmer Smith is using available resources and information for determining required amounts of nutrients per crop based on elemental rate.

Station 3

Custom blended ammonia based nitrogen, liquid phosphorous and potash were chosen as the best management practice to be applied on Farmer John's property. This custom blend was supported by the farm's professional agrologist as a preferred option for fertilizer use.

Answer: Right Source, Farm John understands that this custom blend fertilizer is specific to his local environment, farm, and crop condition present and it is the best source for fertilizer.

Station 4

After assessing local soil and farm conditions on Mr. Pickles pig farm, it was decided that a direct inject application of liquid Nitrogen, Phosphorous, and Potassium (Potash) will be injected 6 to 8 inches underground to prevent nutrient runoff and future algal blooms.

Answer: Right Place, direct inject is an application option but more importantly example states 6-to 8 inches underground which is an example of Right Place, Right Source and/or Right Rate?



4R Station Activity Cards and Answers - Teacher Resource

Station 5

Do we promote growing green water? Name two of the 4Rs and state the rationale for why each R would help prevent a future algal bloom.

Answer:

Right Source – correct source of fertilizer is chosen based on crop type, soils, planting history for the current conditions.

Right Rate – Based on environmental and farm conditions present, the correct amount of fertilizer is applied to be incorporated in plant available form.

Right Time – Correct timing of fertilizer application allows for nutrients to be utilized when plant needs them.

Right Place – would minimize excess nutrient runoff, since adequate amounts are placed where the plant (crop) needs them the most.

Station 6

Variable Rate Technology is a precision agronomy technology that allows producers to vary the rate of crop inputs. Farmers use Variable Rate Technology to choose equipment for apply nutrients at a precise time and/or location to achieve best results for their farm.

Answer: Any or all of the 4Rs are correct.

Any and all of the 4Rs can apply individually or combined for achieving maximum results. Typically used with the help of a computer based modeling program, GIS applications and best management planning. Just one example of an application system using sustainable agriculture.

Station 7

Farmer Jill's tractor uses auto steer and GPS when spraying fertilizer to accurately ensure the nutrients are placed where they can be best used for the crop needs.

Answer:

Right Time, key word here is “placed” as auto steer and GPS are tools used in farming to accurately and precisely identify the best “place” for fertilizer specific to the plants.



4R Station Activity Cards and Answers - Teacher Resource

Station 8

Our neighbours, Mr. & Mrs. Jones, are farmers who decided to use additives in their fertilizer to increase their phosphate efficiency for their crops.

Answer: Right Source, additives are an example of a specific source of fertilizer.

Station 9

This year's record wet spring allowed for excessive amounts of water to remain in and on the fields for months. White salt crystals have formed as a result also known as salinity. The local farmer has decided to test his/her irrigation water on some of the fields and then adjust the application rates based on the amount of fertilizer required.

Answer: Right Rate, based on the "adjustment" of the application rates required for the fertilizer. Too much water, and excessive salinity on the soil are also clues that rate needs to be adjusted for local conditions and seasonal variations.

Station 10

Farmer Catherine decides to use a split application of nitrogen; pre-season urea applications followed by liquid UAN as either a pre-plant or side-dress to assure the right rate is available at critical growth stages for the crop and to minimize N loss to volatilization and leaching.

Answer:
Right Time based on either a pre-plant or side dress for critical growth stages (nutrient use efficiency).





Activity 2: Beat the Bell Printable Station Cards

Instructions

Cut each of the station cards into strips and attach at each station for students.

1 A PEI potato farmer has decided to spring apply fertilizer to his Burbank potatoes rather than apply fertilizer in the fall.

2 Farmer Smith decides to incorporate soil sampling, soil maps as part of his/her 4R plan for determining essential crop needs for application.

3 Custom blended ammonia based nitrogen, liquid phosphorous and potash were chosen as the best management practice to be applied on Farmer John's property.





Activity 2: Beat the Bell Printable Station Cards

Instructions

Cut each of the station cards into strips and attach at each station for students.

4 After assessing local soil and farm conditions on Mr. Pickles pig farm, it was decided that a direct inject application of liquid Nitrogen, Phosphorous, and Potassium (Potash) will be injected 6 to 8 inches underground to prevent nutrient runoff and future algal blooms.

5 Do we promote growing green water? Name two of the 4Rs and state the rationale for why each R would help prevent a future algal bloom.





Activity 2: Beat the Bell Printable Station Cards

Instructions

Cut each of the station cards into strips and attach at each station for students.

#6 Variable Rate Technology is a precision agronomy technology that allows producers to vary the rate of crop inputs. Farmers use Variable Rate Technology to choose equipment for apply nutrients at a precise time and/or location to achieve best results for their farm.

7 Farmer Jill's tractor uses auto steer and GPS when spraying fertilizer to accurately ensure the nutrients are placed where they can be best used for the crop needs.





Activity 2: Beat the Bell Printable Station Cards

Instructions

Cut each of the station cards into strips and attach at each station for students.

8 Our neighbours, Mr. & Mrs. Jones, are farmers who decided to use additives in their fertilizer to increase their phosphate efficiency for their crops.

9 This year's record wet spring allowed for excessive amounts of water to remain in and on the fields for months. White salt crystals have formed as a result also known as salinity. The local farmer has decided to test his/her irrigation water on some of the fields and then adjust the application rates based on the amount of fertilizer required.





Activity 2: Beat the Bell Printable Station Cards

Instructions

Cut each of the station cards into strips and attach at each station for students.

10 Farmer Catherine decides to use a split application of nitrogen; pre-season urea applications followed by liquid UAN as either a pre-plant or side-dress to assure the right rate is available at critical growth stages for the crop and to minimize N loss to volatilization and leaching.



Name/Group:

Date:

**Table 1-1: 4R Student Activity Sheet for Beat the Bell
4R Bell Ringer**

Station ID No.	4R Example (Source, Rate, Time, Place)	Rationale
1		
2		
3		
4		
5		



Name/Group:

Date:

**Table 1-1: 4R Student Activity Sheet for Beat the Bell
4R Bell Ringer**

Station ID No.	4R Example (Source, Rate, Time, Place)	Rationale
6		
7		
8		
9		
10		



Applying 4R Nutrient Stewardship?

Ask students in their groups to think about some examples of variables that may need to be considered when trying to implement a 4R nutrient stewardship management plan.

Materials

- 4R Video with Dr. Robert Coffin (PEI)
- Audio and Video equipment
- 4R Scavenger Items scattered throughout the classroom
- 4R Scavenger checklist (photocopy for each group)

Watch 4R Video: Dr Robert Coffin from PEI speaks about applying 4R nutrient stewardship in PEI and the science behind it.

After the video ask your students to discuss:

- Farmers grow what they can sell, if you were a local farmer, what would you be growing?
- What are the essential elements needed for achieving sustainable agriculture or ingredients for using 4R nutrient stewardship?
- What type of soil would be ideal?
- Does your crop prefer drought or wet conditions?
- Think about the 4Rs and what is best for your crop under local conditions (right source, right rate, right time, and right place). What do you need? Well let's get on our feet and moving. It's time for a 4R scavenger hunt in and around the classroom

4R Scavenger Hunt

To help students think about what variables need to be considered when applying the 4Rs. The purpose is to create an opportunity for students to talk and discuss about what are important factors when considering implementing 4R nutrient stewardship.

Materials

- Small groups of students (2-3)
- Student question sheet
- A box of materials to be hid in and around the classroom or outside the classroom for this exercise.



Student instructions - scavenger hunt

- Check off the list of items that you find and identify how each is related to 4R nutrient stewardship (i.e. some may be variables, some may be examples of one of the 4Rs) Students are asked to move quickly but quietly across the room and discover some of the hidden treasures required for 4R nutrient stewardship and sustainability.
- **A thermometer** - Why would you need one?
- **Seeds** – What are these for?
- **A flat rock** – Why consider rock placement in your fields?
- **A farm photo** – What could this be used for?
- **A map** – Why is a map needed?
- **A label for a bag of fertilizer** – Why do we need to know the amount? What do the numbers mean?





- **An energy source** – Why is this important?
- **A water source** – Why is this important?
- **Ruler** – How can we use this?
- **Calculator** – What do we need this for?
- **An animal which might represent livestock** – How do animals contribute?
- **Nitrogen source** – Why is nitrogen important?
- **Phosphorous source** – Why is phosphorous important?
- **Potash source** – Why is potash important?





Soil - Should we test the soil?



pH paper – How is pH involved?



Calendar – What do I need this for?



4R NUTRIENT STEWARDSHIP: LESSON ONE

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

nutrientsforlife.ca