4R Practices Guidance Document

4R Consistent Practices for Canadian Cropping Systems

Purpose

The 4R Nutrient Stewardship Program is being implemented by the Canadian fertilizer industry to ensure that fertilizers and other nutrient sources are managed sustainably. Awareness of 4R has been steadily increasing among farmers and their crop advisors over the past decade. Increasing interest in developing and implementing 4R Plans has led to questions concerning what are considered best management practices (BMPs). While there is no one right answer to the BMP question, Fertilizer Canada in consultation with industry experts from across Canada has developed this document. The purpose of this document is to provide guidance as to what might be considered 4R consistent practices in different Canadian cropping systems. It also provides some guidance on what would be generally considered less sustainable practices.

The primary target audience for this document is the fertilizer industry. By helping to define 4R practices, it is hoped this document will be useful to industry in development of the 4R Designation Program which includes training of crop advisors, certification of retailers and tracking of acres under 4R management.

Introduction

The 4R Nutrient Stewardship Program uses scientific principles to guide the development of Right Source @ the Right Rate, Right Time, Right Place® practices for different cropping systems (Table 1). While what is Right varies with cropping system, available fertilizer products and application technology; there is an underlying concept that practices selected will balance among economic, environmental, and social considerations. Furthermore, the 4Rs are not independent but highly interdependent and when developing practices for one of the Rights, consideration needs to be given to the other three Rights. **Consequently, best management practices are not stand alone but should be considered as suites of practices that work together toward the goal of improving nutrient use efficiency and reducing nutrient losses from the cropping system**.

Growers are at many different starting points when they first enter into a 4R program. The use of performance levels to group practices provides guidance to growers and their crop advisors on the relative Rightness of practices for the crops and conditions in their region. Performance levels also allow growers to qualify their nutrient management practices as 4R consistent and consequently sustainable against an independent standard. Finally, developing suites of Right practices helps the cropping community move away from practices that are not sustainable.

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Currently the international 4R community is using three performance levels - basic, intermediate, and advanced. The general progression is based on the following concepts:

- *Basic* – Practices are generally consistent with 4R principles. A significant proportion of growers already have these in place or are willing to move to them in the short-term (1-2 years). Current adoption rates may be up to 50% of cropped area in a region.
- *Intermediate* – Practices are fully consistent with 4R principles and may be transitional to advanced practices. Adoption of intermediate level practices may occur over the medium-term (1-3 years) particularly when they involve investment in new technology. Current adoption rates of up to 20% of cropped area in a region.
- *Advanced* – Practices are fully consistent with 4R principles and may be considered aspirational and/or best in class. Adoption of a full suite of advanced level practices may occur over a longer time frame (3-6 years) particularly when they involve investment in new technology. Current adoption rates are generally less than 5% of cropped area in a region.

Determining what practices are included in a given performance level needs to consider the crops, the regional climate, and other localized factors such as soil types. Consequently, there is an element of risk-based flexibility in determining what practices are acceptable for the different performance levels. This means that practices that are Right for a set of crops in one region may not be Right in another. This allows the same practice to be included at a higher performance level when there is sufficient regional evidence to demonstrate low risk and excluded when the evidence indicates high risk. For example, late fall band-application of ammonium based nitrogen sources is considered acceptable at all levels in cold dry winter climates (e.g. the Canadian Prairies) but not in warmer wetter winter regions (e.g. Southern Ontario).

In addition to adherence to 4R principles and the performance level concepts provided above, several additional assumptions were made when developing the practice suites presented here:

Complies with Existing Regulations. Although regulations are in some cases explicitly referenced in the practice suites, the general assumption is that practices picked are/will be compliant with regulations. This is particularly important where the geographic area covered by the practices spans more than one province or territory.

Limited to Nitrogen (N) and Phosphorus (P) Fertilizer. These are the most commonly used nutrients in the cropping systems covered as well as the nutrients that tend to contribute to environmental issues when not well managed.

Practices Do Not Cover Manure Use (Yet). The importance of manure in regions such as Southern Ontario, Southern Alberta, and Southern Manitoba has been noted but manure use practices have not been included in the current set of tables. Cropping systems where manure is regularly applied as a nutrient source have significantly different management requirements than systems that are managed with commercial fertilizer alone. These differences include considerations such as developing phosphorus rates based on more than one year of crop uptake; accounting for ongoing nitrogen mineralization in the years following the year of

application; and developing time and place practices around spreading and incorporation that meet municipal and provincial regulations. The development of the system for tracking implementation of 4R on farm is incremental. 4R consistent practices for managing manure application will be included as the system evolves. In the interim, agronomists and growers are encouraged to follow 4R principles in developing manure recommendations and provincial guidelines when developing manure management plans.

Aimed at Specific Environmental Issues. While improving efficiency and return on investment is an important aim of 4R in all cropping systems, practices were also selected based on their potential to reduce GHG emissions, movement of N to groundwater, and movement of N and P to surface waters. The relative importance of these environmental impacts varies with region and cropping system.

Efficiency Increases with Performance Level. Moving from basic to advanced should follow a trajectory of improved nutrient use efficiency. Although source, rate, time and place practices don't necessarily all change from one level to the next, the changes that are made should lead to higher efficiency overall for each level in the progression. Some of the common themes across cropping systems are shown in Table 2. At present, the actual performance level that a grower can claim for a cropping system is determined by the lowest performance level. For example, a grower with intermediate source, advanced rate, basic time and place would be rated as a basic practitioner. A 4R scorecard is currently under development with the idea that in future growers would be rated along a continuum, rather than the current system of rating on the basis of the lowest of the 4Rs.

Flexible to Accommodate Unusual Circumstances. 4R plans are directional and based on adaptive management. Growers adopt 4R consistent practices, improve over time, and reach a higher level of performance in their nutrient use. Growers may need to break from their intended 4R practices on occasion to accommodate unusual circumstances caused by inclement weather, equipment limitations, lack of product etc. Temporary adoption of practices at a lower performance level than planned or non 4R practices due to uncontrollable factors will in some cases be unavoidable. When this occurs, acres would be counted at the lower performance level or simply not counted for that year.

This document provides an initial set of practice suites for different cropping systems in three areas of Canada: Canadian Prairies, Southern Ontario, and Atlantic Canada in particular Prince Edward Island. In each of those regions suites of practices have been developed at each performance level for one or more important cropping systems.

These practice suites are shown in Tables 3-9. Table 3 shows practices required under the Nitrous Oxide Emission Reduction Protocol (NERP). Note that at present, NERP is part of the regulatory framework for carbon offset trading in Alberta and is highly prescriptive. Table 3 only applies to farms that are enrolled or intend to enroll in a NERP project with a carbon aggregator.

Table 1

Key Scientific Principles Guiding the Development of BMPs for Nutrient Application

Right Source	
1.	Consider Rate, Time and Place
2.	Ensure Balanced Supply
3.	Suit Soil Chemical and Physical Properties
4.	Supply Nutrients in Plant Available Form
5.	Recognize Synergisms Among Nutrients
6.	Recognize Blend Compatibility
7.	Recognize Effects of Associated Elements
8.	Recognize Effects of Non-Nutrient Elements
Right Rate	
1.	Consider Source, Time and Place
2.	Assess Plant Nutrient Demand
3.	Assess Soil Nutrient Supply
4.	Assess All Available Nutrient Sources
5.	Predict Fertilizer Use Efficiency
6.	Consider Soil Resource Impacts
7.	Consider Rate Specific Economics
Right Time	
1.	Consider Source, Rate and Place
2.	Assess Timing of Plant Uptake
3.	Assess Dynamics of Soil Nutrient Supply
4.	Recognize Dynamics of Soil Nutrient Loss
5.	Evaluate Logistics of Field Operations
Right Place	
1.	Consider Source, Rate and Time
2.	Consider Where Plant Roots Are Growing
3.	Consider Soil Chemical Reactions
4.	Suit the Goals of the Tillage System
5.	Manage Spatial Variability

Table 2

Overview of general practice changes from basic to advanced

Level	Source	Rate	Time	Place
Basic	Measured or estimated nutrient content. Known mode of action.	Field specific – the rate is set considering the unique factors in each field.	Reduce high risk timings.	Exclude high risk placement, low efficiency placements.
Intermediate	Enhanced efficiency sources (if available) in high risk situations.	Rate adjusted for subfield variation in soil supply and risk of off-site movement.	Move application timing closer to period of highest crop demand.	Concentrate placement in subsurface bands.
Advanced	Enhanced Efficiency Sources in all but low risk situations.	Rate optimized for subfield variation.	Multiple applications to synchronize timing with crop demand and growing season conditions.	Concentrate placement in subsurface bands in optimal configuration with rooting zone.

4R Consistent Practice Tables

The tables listed below provide an initial set of practice suites for different cropping systems in three areas of Canada: Canadian Prairies, Southern Ontario, and Atlantic Canada in particular Prince Edward Island. In each of those regions suites of practices have been developed at each performance level for one or more important cropping systems. Each table is divided into two parts with the first part covering BMPs for nitrogen and the second part covering BMPs for phosphorus.

Table 3

4R Consistent Nitrogen BMPs for Eligible Annual Crops in the Alberta Nitrous Oxide Emission Reduction Protocol (NERP)

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Ammonium-based formulation. › UAN not eligible for fall application.	› Apply N following 4R plan using annual soil test and/or N balance. › Set field specific rates.	› Apply fertilizer N in spring; or › Split apply; or › Apply N after soil cools in fall.	› Apply in subsurface bands/injection.
Intermediate	› Ammonium-based formulation: and › Use slow/ controlled release fertilizer; or › Inhibitors; or › Stabilized N.	› Apply N according to qualitative estimates of field variability (landscape position, soil variability).	› Apply fertilizer N in spring; or › Split apply; or › Apply N after soil cools in fall if using slow/controlled release fertilizers or inhibitors/ stabilized N.	› Apply in subsurface bands/injection.
Advanced	› Ammonium-based formulation: and › Use slow/ controlled release fertilizer; or › Inhibitors; or › Stabilized N.	› Apply N according to quantified field variability (e.g. digitized zone maps, grid sampling, satellite imagery, real time crop sensors) and complemented by in-season crop monitoring.	› Apply fertilizer N in spring; or › Split apply; or › Apply N after soil cools in fall if using slow/controlled release fertilizers or inhibitors/ stabilized N.	› Apply in subsurface bands/injection.

Table 3 (continued)

SUITES OF 4R P MANAGEMENT PRACTICES CONSISTENT WITH NERP				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Use P fertilizer with guaranteed analysis. *Note: MAP and DAP must be treated as an N source under NERP and meet time and place requirements as outlined above for N.*	› Use recent soil test (3 years or less) to establish P baseline. › Follow provincial guidelines based on soil and crop types to meet sufficiency levels. › Set field specific rates considering differences in yield potential and soil test values among fields. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall band or co-band with N after soil cools.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or co-band prior to seeding or mid-row band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils).
Intermediate	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through, benchmark, zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P in-field in relation to yield potential variations and/or N rates and/or differences in soil test P. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall banded or co-band with N after soil cools.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or co-band prior to seeding or mid-row band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils).
Advanced	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through benchmark, zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P by management zone independently from N. › Apply build rates in fields/ zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in zones that are marginal or optimal in P. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at seeding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Mid-row band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils).

Table 4

4R Practices for Spring Cereal, Oilseed, and Pulse Rotations in the Canadian Prairies without Manure or Compost – Prairie and Boreal Plains Ecozones

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Ammonium-based formulations for fall (UAN excluded due to nitrate content). › Any N fertilizer in spring or in-season. › Inoculate pulse crops. *Exception: Not required for dry beans which are typically fertilized.*	› Set crop and field specific N rates using appropriate regional tools such as nitrate soil tests (surface and subsurface sampling recommended) nitrogen balance, response curves or provincial guidelines. › Consider field specific yield history and soil types in relation to yield potential of other fields on farm and in region, and probabilities for weather variations when setting rates.	› Apply N after soil cools in fall; or › Apply N in spring before or at seeding. › No N application on frozen soil and/or snow covered ground.	› Apply in subsurface bands/injection any acceptable time. › Broadcast and incorporate in spring. › Avoid fall broadcast of unprotected N. › Fall broadcast of enhanced efficiency N fertilizers are acceptable following label instructions regarding incorporation and timing. › Fall broadcast N applied as MAP or DAP with incorporation is acceptable.
Intermediate	› Ammonium-based formulations for fall (UAN excluded due to nitrate content). › Any N fertilizer in spring or in-season. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in situations with higher risk of N loss. › Inoculate pulse crops. *Exception: Not required for dry beans which are typically fertilized.*	› Apply N according to qualitative estimates of in-field variability. › Apply N based on annual soil test using surface and subsurface sampling and/or other estimate of residual nitrogen in combination with estimates of other soil supply sources (mineralization and previous legume crop) and/or crop response curves. › Consider field specific yield history and soil types and probabilities for weather variations when setting rates.	› Apply N after soil cools in fall; or › Apply N in spring before or at seeding; or › Apply in-season. › No N application on frozen soil and/or snow covered ground.	› Apply in subsurface bands/injection. › Broadcast and incorporate in spring. › Use enhanced efficiency ammonium based fertilizers or nitrate based fertilizers (to avoid nitrous oxide emissions from nitrification) for surface applications in spring or in season. › Avoid fall broadcast of unprotected N. › Fall broadcast of enhanced efficiency N fertilizers are acceptable following label instructions regarding incorporation and timing. › Fall broadcast N applied as MAP or DAP with incorporation acceptable.

Table 4 (continued)

4R Practices for Spring Cereal, Oilseed, and Pulse Rotations in the Canadian Prairies without Manure or Compost – Prairie and Boreal Plains Ecozones

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Advanced	› Ammonium-based formulations for fall (UAN excluded due to nitrate content). › Any N fertilizer in spring or in-season. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in situations with higher risk of N loss › Inoculate pulse crops. *Exception: Not required for dry beans which are typically fertilized.*	› Apply N according to quantified field variability using digitized prescriptions (advanced variable rate). › Apply N based on annual soil test using surface and subsurface sampling or other estimate of residual nitrogen such as soil sensors in combination with estimates of other soil supply sources (mineralization and previous legume crop) and/or crop response curves. › Monitor in-season and/or post season using one or more technologies such as ground based crop sensors, satellite or aerial imagery, field scouting, tissue testing, post-harvest soil sampling.	› Apply N after soil cools in fall using enhanced efficiency fertilizer; or › Apply N in spring before or at seeding; or › Apply N in-season. › No N application on frozen soil and/or snow covered ground.	› Apply N in subsurface bands/injection. › Surface N application limited to in-season using surface banded urea with inhibitor, dribble banded UAN, or nitrate based products. › Eliminate fall broadcast of N.

Table 4 (continued)

4R Practices for Spring Cereal, Oilseed, and Pulse Rotations in the Canadian Prairies without Manure or Compost – Prairie and Boreal Plains Ecozones

SUITES OF 4R P MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Use P fertilizer with guaranteed analysis.	› Use recent soil test (3 years or less) to establish P baseline. › Follow provincial guidelines based on soil and crop types to meet sufficiency levels. › Set field specific rates considering differences in yield potential and soil test values among fields. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation or band or co-band.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or Co-band prior to seeding or mid-row band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils). › Surface apply in fields with limited risk of movement to surface waters.
Intermediate	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through zone, grid or benchmark soil sampling. › Consider entire rotation in developing P rates. › Vary P in-field in relation to yield potential variations and/or N rates and/or differences in soil test P. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation or band or co-band.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or Co-band in fall, prior to seeding or mid-row band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils).
Advanced	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P by management zone independently from N. › Apply build rates in fields/ zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in zones that are marginal or optimal in P. › Adopt draw down strategy in zones that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at seeding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Mid-Row Band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils).

Table 5

Corn and Soybean Rotations for Canadian Prairies without Manure or Compost – Prairie and Boreal Plains Ecozones

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Ammonium-based formulations for fall (UAN excluded due to nitrate content). › Any N fertilizer in spring or in-season. › Inoculate soybeans.	› Set crop and field specific N rates for corn using appropriate regional tools such as annual soil tests, nitrogen balance, response curves or provincial guidelines. › Consider field specific yield history and soil types in relation to yield potential of other fields on farm and in region. › Consider probabilities for weather variations when setting rates.	› Apply N after soil cools in fall; or › Apply N in spring before or at seeding; or › No N application on frozen soil and/or snow covered ground.	› Apply in subsurface bands/injection any acceptable time. › Broadcast and incorporate in spring. › Surface application using enhanced efficiency fertilizer. › Avoid fall broadcast of unprotected N. › Fall broadcast of enhanced efficiency N fertilizers are acceptable following label instructions regarding incorporation and timing.
Intermediate	› Ammonium-based formulations for fall (UAN excluded due to nitrate content). › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations. › Inoculate soybeans.	› Apply N according to qualitative estimates of in-field variability. › Apply N based on annual soil test to depth of 24 inches and/or other estimate of residual nitrogen in combination with estimates of other soil supply sources (mineralization and previous legume crop) and/or crop response curves. › Consider in field variability in yield history and soil types and probabilities for weather variations when setting rates.	› Apply N after soil cools in fall using enhanced efficiency fertilizer; or › Apply N in spring before or at seeding; or › Apply in-season. › No N application on frozen soil and/or snow covered ground.	› Apply in subsurface bands/injection. › Broadcast and incorporate. › Use enhanced efficiency ammonium based fertilizers or nitrate based fertilizers (to avoid nitrous oxide emissions from nitrification) for surface applications in spring or in season. › Avoid fall broadcast of unprotected N. › Fall broadcast of enhanced efficiency N fertilizers are acceptable following label instructions regarding incorporation and timing.

Table 5 (continued)

Corn and Soybean Rotations for Canadian Prairies without Manure or Compost – Prairie and Boreal Plains Ecozones

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Advanced	› Ammonium-based formulations. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations. › Inoculate soybeans.	› Apply N according to quantified field variability using digitized zone maps (advanced variable rate). › Apply N based on annual soil test to depth of 24 inches and/or other estimate of residual nitrogen such as soil sensors) in combination with estimates of other soil supply sources (mineralization and previous legume crop). › Monitor in-season and/or post-season N uptake using technologies such as crop sensors, satellite or UAV imagery, crop nitrogen demand modelling, field scouting, corn stalk nitrate testing and fall-nitrate tests.	› Split apply using a combination of spring application at or before seeding or after soil cools in the fall using enhanced efficiency fertilizer, and in-season application. › No N application on frozen soil and/or snow covered ground.	› Apply in subsurface bands/injection. › Surface application limited to in-season using surface banded urea with inhibitor or dribble banded UAN, or nitrate based products. › Eliminate fall broadcast N.

Table 5 (continued)

Corn and Soybean Rotations for Canadian Prairies without Manure or Compost – Prairie and Boreal Plains Ecozones

SUITES OF 4R P MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Use P fertilizer with guaranteed analysis.	› Use recent soil test (3 years or less) to establish P baseline. › Follow provincial guidelines based on soil and crop types to meet sufficiency levels. › Set field specific rates considering differences in yield potential among fields. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation. › Apply P in fall with incorporation or band or co-band.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or Co-band in fall, prior to seeding or mid-row band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils). › Surface apply in fields with limited risk of movement to surface waters.
Intermediate	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through zone, grid or benchmark sampling. › Consider entire rotation in developing P rates. › Vary P in-field in relation to yield potential variations and/or N rates and/or differences in soil test P. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation. › Apply P in fall with incorporation or band or co-band.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or Co-band in fall prior to seeding or mid-row band at seeding (with consideration for mobility issues if banded with high rates of N or in cool soils). › Surface apply in fields with limited risk of movement to surface waters.

Table 5 (continued)

Corn and Soybean Rotations for Canadian Prairies without Manure or Compost – Prairie and Boreal Plains Ecozones

SUITES OF 4R P MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Advanced	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P by management zone independently from N. › Apply build rates in fields/ zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in zones that are marginal or optimal in P. › Adopt draw down strategy in zones that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at seeding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding.

Table 6

Corn and Soybean Rotations in S. Ontario without Manure or Compost – Mixedwood Plains Ecozone

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Any N fertilizer with guaranteed analysis. › Ammonium based NP sources (MAP, DAP, APP) allowed for fall. › Inoculate soybeans.	› Apply based on nitrogen balance or OMAFRA guidelines. › Set field specific N rates for corn considering field specific yield history and soil types in relation to yield potential of other fields on farm and in region. › Consider probabilities for weather variations when setting rates.	› Apply N in spring before or at seeding. › No N application on frozen soil and/or snow covered ground. *Note: N from NP sources allowed for fall.*	› Apply in subsurface bands/injection. › Side-band at seeding. › Broadcast and incorporate.
Intermediate	› Any N fertilizer with guaranteed analysis. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations. › Ammonium based NP sources (MAP, DAP, APP) allowed for fall. › Inoculate soybeans.	› Apply N according to qualitative estimates of field variability (basic variable rate). › Set zone specific N rates considering variability in yield history or potential by zone and soil types. › Apply N based on estimate of residual nitrogen in combination with estimates of other soil supply sources such as mineralization.	› Apply N in spring before or at seeding and/or › No N application on frozen soil and/or snow covered ground. *Note: N from NP sources allowed for fall.*	› Apply in subsurface bands/injection. › Side-band at seeding. › Broadcast and incorporate. › Surface application using enhanced efficiency fertilizer.
Advanced	› Ammonium-based formulations. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations.	› Apply N according to quantified field variability using digitized zone maps (advanced variable rate). › Set zone specific N rates. › Apply N based on estimate of residual nitrogen such as soil sensors) in combination with estimates of other soil supply sources such as mineralization. › Monitor in-season and/or post season N use using technologies such as side-dress nitrate test, crop sensors, satellite or UAV imagery, crop nitrogen demand modelling, field scouting, and corn stalk nitrate testing.	› Split apply N using a combination of spring application at or before seeding and in-season application. › No N application on frozen soil and/or snow covered ground.	› Apply in subsurface bands/injection. › Surface application limited to in-season using surface banded urea with inhibitor, controlled release or dribble banded UAN.

Table 6 (continued)

Corn and Soybean Rotations in S. Ontario without Manure or Compost – Mixedwood Plains Ecozone

SUITES OF 4R P MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Use P fertilizer with guaranteed analysis.	› Use recent soil test (3 years or less) to establish P baseline. › Follow OMAFRA guidelines based on soil and crop types to meet sufficiency levels. › Set field specific rates considering differences in yield potential and soil test values among fields. › P rate when using fall applied NP source (MAP, DAP, APP) should be set such that co-applied N rate does not exceed 50 pounds. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or co-band with other nutrients. › Broadcast and incorporate.
Intermediate	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through zone, grid or benchmark sampling. › Consider entire rotation in developing P rates. › Vary P in-field in relation to yield potential variations and/or N rates and/or differences in soil test P. › P rate when using fall applied NP source (MAP, DAP, APP) should be set such that co-applied N rate does not exceed 50 pounds. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or co-band with other nutrients. › Broadcast and incorporate.
Advanced	› Use P fertilizer with guaranteed analysis.	› Assess in-field variability in P availability through zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P by management zone independently from N. › Apply build rates in fields/zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in fields/zones that are marginal or optimal in P. › Adopt draw down strategy in zones that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at seeding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding.

Table 7

Continuous Corn in S. Ontario without Manure or Compost – Mixedwood Plains Ecozone

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Any N fertilizer with guaranteed analysis for spring. › Ammonium based NP sources (MAP, DAP, APP) allowed for fall.	› Apply based on nitrogen balance or OMAFRA guidelines. › Set field specific N rates for corn considering field specific yield history and soil types in relation to yield potential of other fields on farm and in region. › Consider probabilities for weather variations when setting rates.	› Apply N in spring before or at seeding. › No N application on frozen soil and/or snow covered ground. *Note: N from NP sources allowed for fall.*	› Apply in subsurface bands/injection. › Side-band at seeding. › Broadcast and incorporate.
Intermediate	› Any N fertilizer with guaranteed analysis. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations. › Ammonium based NP sources (MAP, DAP, APP) allowed for fall.	› Apply N according to qualitative estimates of field variability (basic variable rate). › Set zone specific N rates considering variability in yield history or potential by zone and soil types. › Apply N based on estimate of residual nitrogen in combination with estimates of other soil supply sources such as mineralization.	› Apply N in spring before or at seeding. › No N application on frozen soil and/or snow covered ground. *Note: N from NP sources allowed for fall.*	› Apply in subsurface bands/injection. › Side-band at seeding. › Broadcast and incorporate. › Surface application using enhanced efficiency fertilizer.
Advanced	› Ammonium-based formulations. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations.	› Apply N according to quantified field variability using digitized zone maps (advanced variable rate). › Set zone specific N rates. › Apply N based on estimate of residual nitrogen such as soil sensors) in combination with estimates of other soil supply sources such as mineralization. › Monitor in-season and/or post season N use using technologies such as side-dress nitrate test, crop sensors, satellite or UAV imagery, crop nitrogen demand modelling, field scouting, and corn stalk nitrate testing.	› Split apply N using a combination of spring application at or before seeding and in-season application. › No N application on frozen soil and/or snow covered ground.	› Apply in subsurface bands/injection. › Side-band at seeding. › Surface application limited to in-season using surface banded urea with inhibitor or dribble banded UAN.

Table 7 (continued)

Continuous Corn in S. Ontario without Manure or Compost – Mixedwood Plains Ecozone

	SUITES OF 4R P MANAGEMENT PRACTICES			
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Use P fertilizer with guaranteed analysis.	› Use recent soil test (4 years or less) to establish P baseline. › Follow OMAFRA guidelines based on soil and crop types to meet sufficiency levels; or › Set field specific rates considering differences in yield potential and soil test values among fields. › P rate when using fall applied NP source (MAP, DAP, APP) should be set such that co-applied N rate does not exceed 50 pounds. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation or banding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or co-band with other nutrients. › Broadcast and incorporate.
Intermediate	› Use P fertilizer with guaranteed analysis.	› Use recent soil test (4 years or less) to establish P baseline. › Assess in-field variability in P availability through zone, benchmark, or grid sampling. › Consider entire rotation in developing P rates. › Vary P in-field in relation to yield potential variations and/or N rates and/or differences in soil test P. › P rate when using fall applied NP source (MAP, DAP, APP) should be set such that co-applied N rate does not exceed 50 pounds. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at or before seeding. › Apply P in fall with incorporation or banding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Band or co-band with other nutrients. › Broadcast and incorporate.
Advanced	› Use P fertilizer with guaranteed analysis.	› Use recent soil test (4 years or less) to establish P baseline. › Assess in-field variability in P availability through zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P by management zone independently from N. › Apply build rates in fields/zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in zones that are marginal or optimal in P. › Adopt draw down strategy in zones that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in spring at seeding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding.

Table 8

Winter Wheat in S. Ontario without Manure or Compost – Mixedwood Plains Ecozone

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Any N fertilizer with guaranteed analysis for spring application.	› Apply N based on nitrogen balance or OMAFRA guidelines. › Set field specific N rates for winter wheat considering field specific yield history and soil types in relation to yield potential of other fields on farm and in region. › Consider probabilities for weather variations when setting rates.	› Apply required N as soon as practical in spring. › No N application on frozen soil and/or snow covered ground. *Note: N from NP sources (MAP, DAP APP) allowed for fall at P rate.*	› Surface apply in spring.
Intermediate	› Any N fertilizer with guaranteed analysis for spring application. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations.	› Apply N according to qualitative estimates of field variability. › Apply N based on estimates of residual nitrogen in combination with estimates of other soil supply sources (mineralization, previous soybean or other legume crop).	› Apply required N as soon as practical in spring. › No N application on frozen soil and/or snow covered ground. *Note: N from NP sources (MAP, DAP APP) allowed for fall at P rate.*	› Surface apply in spring.
Advanced	› Any N fertilizer with guaranteed analysis for spring application. › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) in high moisture, high risk situations.	› Apply N according to quantified field variability using digitized zone maps (advanced variable rate). › Apply N based on estimates of residual nitrogen in combination with estimates of other soil supply sources (mineralization and previous legume crop). › Monitor in-season and/or post season N using technologies such as crop sensors, satellite or UAV imagery, crop nitrogen demand modelling, field scouting, and tissue testing.	› Split apply N using a combination of spring application as soon as practical and in-season application. › No N application on frozen soil and/or snow covered ground. *Note: N from NP sources (MAP, DAP APP) allowed for fall at P rate.*	› Surface application in spring and/or in-season using surface banded or broadcast urea with inhibitor, controlled release, or broadcast ammonium nitrate or dribble banded UAN, or › Apply in subsurface bands/injection using specialized equipment.

Table 8 (continued)

Winter Wheat in S. Ontario without Manure or Compost – Mixedwood Plains Ecozone

SUITES OF 4R P MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Use P fertilizer with guaranteed analysis.	› Use recent soil test (4 years or less) to establish P baseline. › Follow OMAFRA guidelines based on soil and crop types to meet sufficiency levels. › Set field specific rates considering differences in yield potential and soil test values among fields. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in fall at or before seeding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Subsurface band prior to seeding. › Surface apply only in fields with limited risk of movement to surface waters.
Intermediate	› Use P fertilizer with guaranteed analysis.	› Use recent soil tests (4 years or less) to establish P baseline. › Assess in-field variability in P availability through zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P in-field in relation to yield potential variations and/or N rates and/or differences in soil test P. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in fall at or before seeding.	› Place with seed at safe rates based seed bed utilization, and total product load. › Side-band at seeding. › Subsurface band prior to seeding. › Surface apply in fields with limited risk of movement to surface waters.
Advanced	› Use P fertilizer with guaranteed analysis.	› Use recent soil tests (4 years or less) to establish P baseline. › Assess in-field variability in P availability through zone, benchmark, or grid sampling. › Consider entire rotation in developing P rates. › Vary P by management zone independently from N. › Apply build rates in zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in zones that are marginal or optimal in P. › Adopt draw down strategy in fields that test very high in P (approaching or exceeding 60 ppm) by setting rates less than annual crop removal.	› Apply P in fall at or before seeding.	› Place with seed at safe rates based on crop, seed bed utilization, and total product load. › Side-band at seeding. › Subsurface band prior to seeding.

Table 9

Intensive Potato Rotation Prince Edward Island – Atlantic Maritime Ecozone

SUITES OF 4R N MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Any N fertilizer with guaranteed analysis.	› Apply based on nitrogen balance or provincial guidelines for yield goals. › Set field specific rates based on previous yield history and soil types. › Adjust for variety following provincial guidelines.	› Apply nitrogen in spring before or at seeding. › No N application on frozen soil and/or snow covered ground.	› Broadcast and incorporate. › Use enhanced efficiency fertilizers where incorporation is not possible following pre-plant surface application.
Intermediate	Same as Basic, plus: › Use enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) should account for at least 33% of total N application.	Same as Basic, plus: › Adjust N rates based on estimates of residual nitrogen in combination with estimates of other soil supply sources (mineralization, previous pulse or other legume crops). › Build N rate strategy based on well-developed field management zones adjusting N rates according to estimates of field variability.	› Split nitrogen between before or at seeding and one or more in-season applications.	› Apply in subsurface bands/injection. › Limit surface application to in-season.
Advanced	Same as Intermediate, plus: › Use of enhanced efficiency fertilizers (nitrification inhibitors, urease inhibitors, or controlled release) should account for at least 50% of total N application.	Same as Intermediate, plus: › Apply N according to quantified field variability using digitized zone maps (advanced variable rate). › Monitor in-season and/or post season N use using technologies such as crop sensors, satellite or UAV imagery, crop nitrogen demand modelling, field scouting, and petiole testing.	› Split nitrogen between before or at seeding and one or more in-season applications.	› Apply in subsurface bands/injection. › Limit surface application to in-season using surface banded urea with inhibitor, controlled release, or dribble banded UAN.

Table 9 (continued)

Intensive Potato Rotation Prince Edward Island – Atlantic Maritime Ecozone

SUITES OF 4R P MANAGEMENT PRACTICES				
Level	**Right Source**	**Right Rate**	**Right Time**	**Right Place**
Basic	› Use P fertilizer with guaranteed analysis. › Use P sources capable of enhancing P availability to level of crop demand in current growing season.	› Use recent soil test (3 years or less) to establish P baseline. › Set field specific rates considering differences in soil test values among fields.	› Apply P in fall with incorporation.	› Broadcast and incorporate. › Surface apply only in fields with limited risk of movement to surface waters.
Intermediate	› Use P fertilizer with guaranteed analysis. › Use P sources capable of enhancing P availability to level of crop demand in current growing season.	› Consider entire rotation in developing P rates. › Vary P among fields in relation to yield potential variations and/or N rates and/or differences in soil test P. › Apply build rates in fields/ zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in zones that are marginal or optimal in P. › Adopt draw down strategy in fields that test very high in P by setting rates less than annual crop removal.	› Apply P in spring before seeding.	› Band before or at seeding. › Broadcast and incorporate (only an intermediate BMP when P is already optimal and P rates are removal based).
Advanced	› Use P fertilizer with guaranteed analysis. › Use P sources capable of enhancing P availability to level of crop demand in current growing season.	› Assess in-field variability in P availability through zone or grid sampling. › Consider entire rotation in developing P rates. › Vary P by management zone independently from N. › Apply build rates in fields/ zones that are deficient or very deficient in P. › Apply only removal or sufficiency rates in zones that are marginal or optimal in P. › Adopt draw down strategy in fields that test very high in P by setting rates less than annual crop removal.	› Apply P in spring at seeding.	› Side-band at seeding.

Table 10

Glossary

Term	Definition
Advanced Variable Rate	Nutrients are varied in accordance with quantitative assessment of field variability based on digital application prescriptions derived from one or more of the following technologies for estimating nutrient variability at the sub field levels: aerial or satellite imagery, grid soil sampling, yield maps, digitized zone maps, and in-field sensors.
Ammonium based formulation	Any fertilizer which releases more than two-thirds of its N in the ammonium form. For example, urea is considered an ammonium based fertilizer since the product of urea hydrolysis is ammonium.
Basic Variable Rate	Nutrients are varied at the sub-field level in accordance with qualitative assessment of field variability.
Co-band	Banding two or more nutrients together using two or more sources.
Enhanced Efficiency Fertilizers	Fertilizer sources or products that enhance the availability of fertilizer nutrients by maintaining the nutrients in available form and/or preventing losses from the cropping system. Common technologies used in EEFs include polymer coatings, nitrification inhibitors, and urease inhibitors.
Crop Models	In the context of 4R, crop models are computer models capable of predicting cropping system variables important to nutrient management decisions such as weather, crop stage, nutrient demand or nutrient availability. They can include mechanistic, stochastic, or statistical approaches including the emerging field of big data analytics. Acceptable models will have been calibrated and validated for the cropping systems in which they are being used.
Crop and field specific rates	4R treats each field as a unique cropping system. Crop and field specific rates implies that the unique requirements of a field and the crop are considered when setting rates within the logistical and operational constraints of the farm.
Grid Sampling	A soil sampling protocol in which samples are taken at preassigned points on a regular grid within a field.
Subsurface Sample	Typically, a 6-24 or 12-24 inch sample depending on surface sampling depth. In some cases, a 6-12 and 12-24 sampling is used. Soil test N has generally been calibrated to cumulated soil test N to a depth of 24 inches (surface plus subsurface). Labs can adjust values when the full 24 inch depth cannot be reached due to soil conditions or other limitations.
Surface Sample	Typically, a 0-6 inch or 0-12 inch sample. Soil test P has generally been calibrated to a 0-6 inch sample in Canada.
Sufficiency and/ or Sufficiency Recommendation	Recommendations based on Liebig's Law of the Minimum. Sufficiency recommendations are designed to meet the nutrient needs of the current crop by supplying those nutrients that are yield limiting.
Zone Sampling	A stratified random sampling protocol based on dividing the field into management or production zones based on satellite imagery, electrical conductivity maps, yield maps, soil maps and/or other information and then sampling each zone separately.

4R Inside Check List

Is your nutrient management system 4R consistent? The 4R Nutrient Stewardship concept defines the right source, rate, time, and place for plant nutrient application as those producing the economic, social, and environmental outcomes desired by all stakeholders in the soil-plant system. The 4R approach is based on using Best Management Practices (BMPs) derived from the best available science to manage nutrient resources in ways that increase sustainability. The following checklist outlines the requirements for compliance with 4R Nutrient Stewardship standards. Meeting the standards allows producers, service providers, educators, and policy makers to be assured that their programs follow 4R Nutrient Stewardship.

Does your nutrient management program:

- Balance the three areas of sustainability – economic, social, and environmental.
- Includes BMPs that integrate solutions for all 4R performance areas – source, rate, time and place.
- Provide site-specific recommendations that address specific regional soil, climate and operational issues.
- Balance nutrition to ensure that N, P, K, secondary nutrients and micronutrients are in adequate supply to meet crop production expectations.
- Use appropriate tools such as soil testing, tissue testing, and nutrient balance to assess nutrient requirements.
- Consider all sources of nutrients (fertilizer, soil organic matter, manure, crop residue etc.) during planning and recommendation development.
- Comply with applicable nutrient management regulations in your region.
- Measure the effectiveness of selected BMPs and use assessments to support continuous improvement.
- Use concepts and terminology consistent with defined 4R standards.
- Provide and maintain clear documentation of the nutrient management plan and its implementation.

FERTILIZER CANADA
FERTILISANTS CANADA

4 nutrient stewardship