Canadian Fertilizer Institute
Institut Canadien des Engrais

4R NUTRIENT STEWARDSHIP: Prince Edward Island

2014 4R Demonstration Farm Report

nutrient stewardship

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Introduction

Nutrient management — 4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place®) strategies for fertilizing potato crops under Prince Edward Island conditions were introduced to the island (PEI) industry in 2013 via a series of field-scale demonstration trials conducted by Genesis Crop Systems Inc. (GCS) under contract to the Canadian Fertilizer Institute (CFI).

Results from year 1 appeared quite promising. The 4R treated field areas produced crops with equivalent or better economic value and quality at four of the five locations (site 5 data was discounted due to a nutrient application issue with a disk spreader) as compared to the grower standard practice (GSP) fertility strategies in the same field. Potatoes grown using the 4R strategy also had less residual N and P_2O_5 remaining after harvest, suggesting a reduction in the potential environmental risk as compared to areas grown using GSP fertilizer programs.

As the results from Year 1 increased producer interest, project activities for 2014 were increased to include 13 sites. Two of these sites had irrigation capacity in some areas of the field. These fields were sub-divided into irrigated and non-irrigated sections, thus creating a total of 15 sites for the season.

Methodology:

GCS engaged 13 PEI producers to participate in the demonstration trials. Participants included:

1. MacLennan Properties, West Cape
2. Link Agro-Services, Linkletter
3. Island Holdings, New Annan
4. Hunter Farms, Indian River
5. Oyster Cove Farms, Hamilton
6. Willard Waugh & Sons, Bedeque
7. Birch Farms, Bedeque
8. Martin Visser & Sons, Victoria
9. Harold Godfrey & Son, Cornwall
10. Brian & Scott Annear, Montague
11. Wayne & John Townshend, Fortune
12. Mo'Dhaicd'h Farms, Marie
13. Rollo Bay Holdings, Rollo Bay

Figure 1 provides an overview of farm location. Sites were implemented at all major island production areas and included crops planted for processing and seed use. Five of these farms participated in the 2013 trials and were eager to continue in 2014.

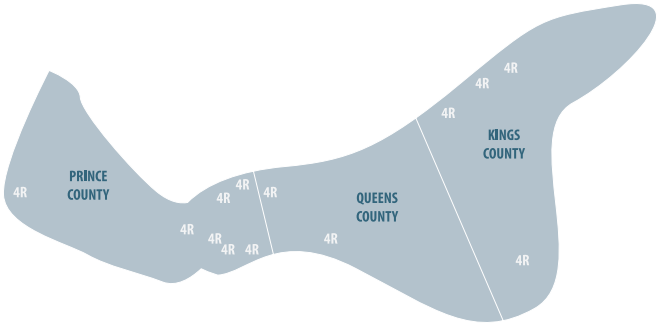

Figure 1: PEI 2014 — CFI 4R Demonstration Sites.

Following grower field selection, GCS reviewed the current soil test report, previous crop history, organic amendment application (if applicable), variety, and end use for each site. A 4R program was then developed for each site based on these parameters. Growers were asked to treat a section in the field at least 10 acres in size with the recommended 4R fertility protocol. An area of at least equal size and positioned immediately adjacent to the 4R plot was managed using the GSP.

4R program strategies included:

- Split N applications into two or three applications including a reduced level of N in the planter mix as compared to the GSP treated areas. A number of sites also featured reductions in total N application by 10 to 20 per cent based on grower soil test.
- Reduced application of P_2O_5. Most soils in the potato growing areas of the province have high levels of P_2O_5 and likely do not require the P_2O_5 application amounts that are currently popular among many growers. Local Agriculture and Agri-Food Canada research is concentrating on the development of Phosphorous Saturation Indices which may be utilized to assist in identifying if reduced levels of phosphorus application may be feasible in the future.
- Potash (K_2O) application was split applied as pre-plant broadcast/incorporated (Muriate of Potash [MOP]) and banded at planting from a combination of KMag and Sulfate of Potash. The traditional GSP K_2O program involves almost exclusive use of MOP which increases the salt concentration around the tuber zone. Research has indicated that the chloride ion (in MOP – KCl) may be associated with reducing tuber dry matter content which is an undesirable attribute in potatoes destined for the processing market. Broadcast, rather than banding, application of MOP can help alleviate this effect.

- Magnesium (Mg), Boron (B) and Zinc (Zn) can be quite low in many island fields and have been added to programs where soil tests indicated a potential crop response would occur as a result of their inclusion.
- All growers were asked to avoid application of any foliar fertilizer products on the 4R sections of the field unless advised by GCS.

Prior to any nutrient application, GPS reference points were established and soil samples collected from 0-6", 6-12", and 12-18" depths. These and all subsequent soil/plant material samples were delivered to the PEI Soils Lab for analysis. Growers then commenced with normal crop production activities, ensuring that a clear line dividing the fertilizer programs was established.

Mid-season soil and tissue samples were collected at time of full row closure. Soil samples were collected from each GPS reference point directly between plants in the middle of the row with the objective of splitting the fertilizer bands. Fifty petioles and five whole plants (foliage, roots, and tubers) were also collected from each treatment and submitted for analysis.

Demo Farm Profile

Shawn & Corey Birch
Location: Lower Bedeque, PEI

"4R Nutrient Stewardship is a win-win situation for farmers, consumers, and the environment. Everyone benefits when we can make sure our inputs, such as fertilizer, stay where they are placed."

Prior to commercial harvest, 6' x 15' sections of row, each containing the same number of plants, were hand harvested from each treatment at each site. These samples were placed in storage for subsequent grading and evaluation. Post-harvest soil samples were collected as described earlier and submitted for analysis.

Four 4-6 ounce tubers were collected from each sample and composites formed from each treatment. Twelve tubers from each composite were submitted to the Soil Testing Lab for nutrient content; twelve were placed in long term storage for winter-spring French fry quality evaluation. All remaining tubers were delivered to Cavendish Farms Central Grading Facility for yield and quality analysis and establishment of gross crop values for each treatment.

Results:

Crop Performance & Economics

Per acre costs of implementing 4R strategies vary depending on the individual growers' current fertilizer strategy. Any incremental (or reduced) costs associated with 4R applications have been accounted for and are reported in the Change in Net Crop Value sections of the appropriate data tables on a cost per acre basis. Results to date indicate that the implemented 4R programs generally ranged from $60 less to $50 more per acre when compared to their respective GSP. In several cases, reduced costs associated with lower rates of N and/or P_2O_5 have been offset by the increased cost of using products such as KMag and Sulfate of Potash. Most importantly, implementation of a 4R program has been shown to positively impact the end net crop value regardless of the potential change in the cost per acre.

The physical appearance of foliage in most of the 4R-treated Russet Burbank was consistent to that observed in 2013 trials (Figure 2) — paler green in colour and less foliar canopy growth than the GSP treated areas. This is most likely a result of the N application/timing as part of the 4R program which allows the N to be taken up by the crop in smaller amounts over a longer duration as opposed to having the majority of N applied in the fertilizer bands at planting time with most GSP treatments. Visual difference in the foliage color in most other varieties was less pronounced or not detected.

Major parameters presented in Tables 1-3 include total tuber yield, percentage of tubers under 2"

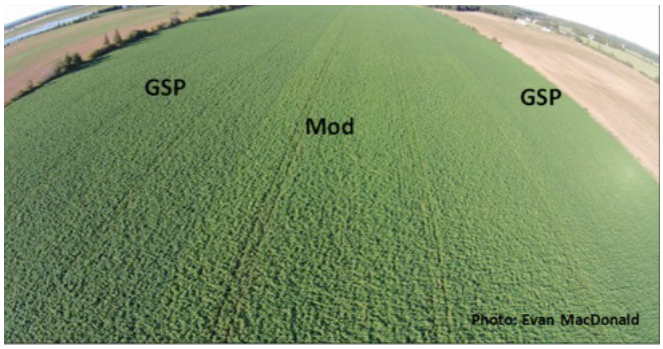

Figure 2: Foliage differences between GSP and Modified 4R fertility treatments at Site L on Sept 8, 2014.

diameter, percentage of tubers greater than 10 ounces, total defects, tuber specific gravity (dry matter), and change in net crop value of the 4R program as compared to the GSP program. Net crop value takes into account potential differences of implementing the 4R program including differences in the source and rate of nutrients applied and differences in cost to application methods. Crop value calculation is based on the PEI Period 11 French Fry contract. It should be noted that several of the fields were planted for use other than French fries and end use crop value will vary from that presented in this report.

9 of the 15 sites were successfully implemented without problems and are representative of the 4R concepts being tested in these trials. While total yield values were relatively similar at many sites, other factors such as size profile and specific gravity values resulted in changes in the net value of the crop at some locations. There were instances where the 4R crop yield and/or net crop value was lower than the GSP area from a numerical sense, but most data seemed to trend towards equal or better performance for the 4R treatments.

A few sites experienced unique conditions which created a need for the data to be separated into three discreet sections for comparison. One field (C) had treatments separated by a berm and rows planted in opposite orientation. Field H (one of the irrigated fields containing two individual sites) did not have the top dress N applied correctly (before final hilling procedure — this application accounted for 33 per cent of the total N requirement). Data collected from these three sites was recorded and is presented in Table 2, but should not be used as an indication of the validity of the 4R concept.

Interestingly, 4R yields, quality, and net crop value improved at Site J where irrigation water was applied. This may have helped drive the later misapplied Nitrogen into the hill where it was at least partially utilized by the crop.

Three fields experienced excess dockage due to higher than normal wireworm or pitted scab infestation in some strips. This resulted in changes in net crop value which also should not be considered indicative of the fertilizer program. Data from these three sites is presented in Table 3. There is no logical explanation for the excessive wireworm damage at the GSP plots at Site K. There is also no logical explanation for increased Pitted Scab deducts in 4R plots at Sites L & D either, as additional Sulfur application is a practice commonly used to reduce incidence of Potato Scab in many Northeast North American potato fields. Total yields before dockage were similar for both treatments and there is no reason to believe that either fertilizer program could be to blame for the increase in dockage levels. Once again, these data should not be used to validate the effects of the 4R strategy.

Demo Farm Profile

Brian Annear
Location: Brudenell, PEI

"Our farm believes strongly that proper use of fertilizer is not only vital to our operation, but also economical and environmentally friendly to Prince Edward Island's natural resources."

Table 1. Major Crop Parameter Results for the 2014 PEI 4R Trial at Sites A, B, E, F, G, H, M, N & O.

Grower	Variety / End Use	Program	Yield (cwt/acre)	% smalls	% 10 oz	Total Defects	Sp. Gr.	Net change in crop value (4R vs GSP)
A	Prospect FF	GSP	301	6	27	7.3	1.091	
		4R	295	5	25	3.2	1.089	45
B	R Burbank FF	GSP	350	6	60	13.5	1.086	
		4R	319	8	53	10.3	1.087	-201
E	Superior Seed	GSP	247	7	9	12.2	1.080	
		4R	316*	8	3	7.5	1.086*	690*
F	Sifra Seed	GSP	324	22	5	2.2	1.077	
		4R	333	22	3	2.3	1.075	-21
G	R Burbank Dry FF	GSP Dry	288*	11	37	5.3	1.086	
		4R Dry	254	16	28	9.5	1.084	-519*
H	R Burbank Irr FF	GSP Irr	279	14	28	6.3	1.086	
		4R Irr	277	12	33	6.3	1.092	88
M	R Burbank FF	GSP	271	15	39	8	1.082	
		4R	296	15	29	1.7	1.087*	411
N	R Burbank FF	GSP	285	10	53	4.8	1.088	
		4R	297	13	37	4	1.086	88
O	Prospect FF	GSP	283	12	8.5	1.3	1.088	
		4R	289	5	26	3	1.086	183
O	Prospect FF	GSP	283	12	8.5	1.3	1.088	
		4R	289	5	26	3	1.086	183
Average of all Nine Sites								85

* Denotes a significant difference from the other treatment at 95% confidence interval. Statistical analyses performed only on yield, specific gravity and net change in crop value ($/acre) results.

The Environmental Aspect

Mid-season petiole/whole plant analysis data are presented along with all project soil analysis data in Appendices 1A — 1C. Similar to last year, there were no large differences noted between fertilizer programs. Nitrogen levels in petioles at some sites were lower in the 4R treated areas. This may help explain the lighter green foliage and smaller plant canopy observed at several sites. Otherwise, only minor variations where seen in petiole/whole plant values.

Aside from tuber dry matter values (results similar to specific gravity values from Cavendish Farms Grading Facility), no other major differences were observed in the tuber analysis data. Major nutrient content was similar in the harvested tubers, regardless of the fertilizer program.

Nutrient balance data are presented in Table 4. This data represents values of total N – P_2O_5 – K_2O applied, total amounts removed in harvested tubers, and total amounts left in the field that have the potential to pose a risk if lost to the environment. Nitrogen and phosphorous values are used for discussion purposes here; potassium is normally not associated with environmental issues in agriculture. Growers may choose to strive to improve overall

Table 2. Major Crop Parameter Results for the 2014 PEI 4R Trial at Sites C, I & J.

Grower	Variety / End Use	Program	Yield (cwt/acre)	% smalls	% 10 oz	Total Defects	Sp. Gr.	Net change in crop value (4R vs GSP)
C	GoldRush Fresh	GSP	307*	12	30	1.8	1.078	
		4R	270	18	14	3	1.083*	-378*
I	R Burbank Dry FF	GSP Dry	372*	12	34	24.5	1.084	
		4R Dry	280	18	32	27	1.089*	-786*
J	R Burbank Irr FF	GSP Irr	325	11	40	12.8	1.082	
		4R Irr	318	12	34	11	1.085	136

* Denotes a significant difference from the other treatment at 95% confidence interval. Statistical analyses performed only on yield, specific gravity and net change in crop value ($/acre) results.

Demo Farm Profile

Kevin Hunter
Location: Irishtown Rd, PEI

"4R Nutrient Stewardship is based on the principle of adaptive management and continuous improvement. From year to year, we can assess what we've done and make incremental changes in our farming practices to ensure fertilizer is used more effectively."

soil levels in their potato fields providing they choose the right source and the right application method.

All sites had less leftover N on the balance sheet in the 4R treated areas, with the exception of one which had the same value in both the 4R and GSP treated fields. PEI 4R research has shown that current potato crop yields tend to remove no more than 90-120 lbs of N per acre. Interestingly enough, it would require yields much higher to remove the excess N from the balance sheet for many of the GSP treated fields in this study.

Total NO_3 – N values collected post-harvest to a depth of 18" are presented in Table 5. Fields under 4R management had lower NO_3 – N levels at 8 of 10 locations. Lower NO_3 – N levels, such as those found within the 4R sites within this study, may present less potential environmental loss than that observed within the GSP sites. Obviously some N remains in the field in the crop debris of both treatments, however this source of N should not be considered an immediate risk to the environment while it remains in an organic form.

Phosphorous balance sheet levels were also lower in most 4R treated fields (12 of 13). Phosphorous efficiency seemed to be more difficult to predict. All 4R sites utilized P_2O_5

Table 3. Table 3. Major Crop Parameter Results for the 2014 PEI 4R Trial at Sites L, K & D.

Grower	Variety / End Use	Program	Yield (cwt/acre)	% smalls	% 10 oz	Total Defects	Sp. Gr.	Net change in crop value (4R vs GSP)
L	Ranger Russet FF	GSP	301	8	51	4	1.09	
		4R	294	6	44	7.8	1.09	-119
K	R Burbank FF	GSP	280	19	13	19.8	1.091	
		4R	288	6	27	5.6	1.089	701
D	Shepody FF	GSP	243	14	23	5	1.089	
		4R	253	16	20	13.5	1.09	-139

Statistical analyses were performed on yield, specific gravity and net change in crop value($/acre) results. There was found to be no significant difference between these two treatments at all three sites.

application rates of 10 to 30 per cent less than their corresponding GSP regimes and did not appear to be the cause of any loss in economic value. It is important to remember however, that the 4R approach applies to a soil system involving numerous plant nutrients interacting together to form dynamic and interrelated relationship. It can therefore be difficult to evaluate the effect of changing of any one individual plant nutrient in particular on the system as a whole.

Conclusions:

Data presented in this report support the use of 4R concepts for producing potatoes in Prince Edward Island. Applicable trials conducted at numerous sites during the 2013 and 2014 growing seasons have demonstrated that introducing subtle changes to the way the crop is fertilized can produce crops with at least as much economic value (note — the goal here is to eventually increase economic value on a consistent basis) as the current level of management while lessening potential environmental risk.

Demo Farm Profile

Jonathan Maclennan
Location: West Cape, PEI

"Economic, social, and environmental considerations have always been important on our farm, but by having a structured program like 4R Nutrient Stewardship, we are able to showcase our sustainability program and improve on our practices."

Table 4. Nutrient Balance Sheet for all sites from the 2014 PEI 4R Trials.

Site	Treatment	Nutrients applied (lbs)			Nutrients removed (lbs)			Balance		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
A	GSP	136	136	145	103	40	155	33	96	10
	4R	120	110	155	107	32	155	13	78	8
B	GSP	190	150	150	123	30	174	67	120	-24
	4R	178	115	144	111	27	160	67	88	-16
C	GSP	191	180	253	98	35	146	93	145	107
	4R	180	120	120	93	28	118	87	92	2
D	GSP	180	160	207	90	30	119	90	130	88
	4R	180	120	170	94	32	118	86	88	52
E	GSP	173	173	168	80	29	106	93	144	62
	4R	166	149	140	107	37	129	59	112	11
F	GSP	137	137	156	101	37	125	36	100	31
	4R	120	153	166	100	37	135	20	116	29
G	GSP	200	125	227	96	26	133	104	99	94
	4R	181	126	249	96	30	138	85	96	111
I	GSP	200	176	287	119	39	170	81	137	117
	4R	177	154	246	100	26	125	77	128	121
K	GSP	190	180	244	105	26	140	85	154	104
	4R	176	147	295	108	26	150	68	121	145
L	GSP	180	197	297	107	42	157	73	155	140
	4R	163	154	213	111	38	167	52	116	46
M	GSP	193	202	243	91	35	161	102	167	82
	4R	180	153	286	105	27	158	75	126	128
N	GSP	205	160	250	104	27	144	101	133	106
	4R	183	133	347	100	26	160	83	107	187
O	GSP	130	150	150	102	36	125	28	114	25
	4R	119	144	318	98	35	142	21	109	111

Table 5. Post-harvest residual soil nitrate levels within the first 18" of soil within 10 sites of the 2014 PEI 4R Trials. Note: sites E, G, H, I, & J data is unavailable.

Site	Soil NO3 levels (ppm)		Reduction (Yes/No)	Percent change comparison (4R vs GSP)
	GSP	4R		
A	42.9	28.6	Y	-33
B	126	79	Y	-37
C	38	35.4	Y	-7
D	28.7	45.2	N	57
F	33.4	22.9	Y	-31
K	58.7	41	Y	-30
L	75.2	55.2	Y	-27
M	100.1	111.3	N	11
N	76.2	56.6	Y	-26
O	10.3	7	Y	-32

Demo Farm Profile

Willard Waugh & Sons
Location: North Bedeque, PEI

"On our farm, we want to ensure profitability and see improved return on investments while taking into account the health of our soils. The 4R framework is able to provide us with a system for making that happen while demonstrating that our farm operation is sustainable."

The programs evaluated to date can be considered as "works in progress" and have helped increase grower awareness of the 4R approach. The main objective is to *"continue to identify and demonstrate"* new and modern methods of fertilizing the potato crop that will meet the goals of the producer, the environment, and society in general.

Acknowledgements:

GSC wishes to acknowledge the assistance of the following growers and organisations that assisted with the implementation of this work:

- All growers — MacLennan Properties, Linkletter Farms, Oyster Cove Farms, Hunter Farms, Island Holdings, Willard Waugh & Sons, Birch Farms, Martin Visser & Sons, Harold Godfrey & Son, Brian & Scott Annear, Rollo Bay Holdings, Wayne & John Townshend and Mo'Dhaicd'h Farms
- Staff from the Prince Edward Island Department of Agriculture and Forestry and the PEI Analytical Laboratory
- Staff from Cavendish Farms Research Division and Central Grading Facility