Progress Report

Vauxhall Irrigated Rotation Study

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1. Project Title: Irrigated Cropping Systems for Sustainable Management

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3. Funding Agencies: Alberta Agricultural Research Institute (AARI)-Farming for the Future Research Funding Program, Potato Growers of Alberta, Alberta Pulse Growers (Provincial and Zone 1); Rogers Sugar Ltd., AAFC-MII.

4. Project Duration: ongoing

5. Objectives: To devise crop sequences and tillage management systems for irrigated land that: 1) reduce soil erosion, enhance soil quality and ensure long-term sustainability; and (2) minimize weed and disease problems.

6. Summary of progress in 2003:

Experimental Treatments
The following crop rotations were established in spring 2000 at the Vauxhall Sub-station of Agriculture and Agri-Food Canada. The 2003 growing season represented the 4th crop year of this study.

	Rotation	Management
1Yr	W	Cont. wheat (baseline)
3Yr	(P-B-W)c	Conventional
3Yr	(P-B-W)s	Sustainable
4Yr	(W-SB-B-P)c	Conventional
4Yr	(W-SB-B-P)s	Sustainable
5Yr	P-W-SB-W-B	Sustainable (cereal break)
6Yr	O(T)-T-T-SB-B-P	Sustainable (forage-based)

W = wheat; P = potatoes; B = beans; SB = sugar beet; O = oats, T = timothy.

Each phase of each rotation was represented resulting in 26 treatments. These were replicated four times to give 104 plots. The plot dimensions were 10 x 18.3 m with a 2.1 m interplot area between each plot.

The sustainable rotations are built around four specific management practices:
(1) direct seeding or reduced tillage where possible
(2) fall-seeded cover crops where possible
(3) composted cattle manure as a substitute for inorganic fertilizer
(4) straight cutting of solid seeded rather than undercutting of wide-row seeded beans

Weather Conditions
The 2003 April-September or growing season precipitation was 222 mm which was slightly below the long-term mean (1954-2002) of 243 mm (Table 1). The season was characterized by a very wet April (2.4 times normal precipitation) and wetter-than-normal May. About 35 cm of

snow fell at Vauxhall on May 3-4, 2003. This led to severe flooding on the plot area with the result that water had to be pumped off. It also delayed planting of some plots, leading to different planting dates for the same crop (wheat, oats, potatoes). Another issue was soil crusting which prevented emergence, especially of some wheat and oat plots. This necessitated working these plots to break the crust and re-seeding them. This was followed by a drier-than normal June-September period. July and August were especially dry at only 46% and 33% of normal, respectively. Overall, temperature conditions were about 0.5 °C warmer than normal for the April-September growing season. May was 1.3 °C cooler than normal while August was 2.1 °C warmer-than normal (Table 1).

Table 1. Vauxhall precipitation and air temperature (2003) and long-term mean (1954-present).

	Precipitation, mm		Temperature, °C	
	2003	Long Term Mean	2003	Long Term Mean
Jan	11.2	16.9	-6.6	-9.8
Feb	14.8	11.8	-7.8	-6.1
Mar	26.1	17.0	-3.0	-1.5
Apr	69.9	29.4	6.8	5.6
May	56.6	42.0	10.2	11.5
Jun	40.6	64.1	15.8	15.9
Jul	15.8	34.6	19.3	18.6
Aug	12.3	37.1	20.0	17.9
Sep	26.4	36.1	12.8	12.5
Oct	21.9	14.6	8.8	6.8
Nov	17.9	13.8	-7.3	-1.4
Dec	9.5	15.2	-3.3	-7.0
Total	323.0	332.6		
Apr-Sep.	222	243	14.2	13.7

Bean Yields

In total there were 24 bean plots on the study (6 rotations x 4 reps). Black beans (UI 406) were seeded on the conventional plots [3yr and 4 yr-c rotations (8 plots) at a wide row spacing of 60-cm] on May 22, 2003. The sustainable rotations (3 yr-s, 4 yr-s, 5 yr and 6 yr, 16 plots) were seeded on May 28 with a John Deere 1560 no-till drill at a narrow-row spacing (20 cm). Due to high weed populations, the narrow-row beans were hand-harvested (6 m^2 per plot) on September 8, 2003. The wide-row beans were undercut on August 29, 2003 and harvested by plot combine on September 23, 2003. Harvest was delayed by 18.4 mm of precipitation between September 14-21, 2003.

Unlike, all three previous years in this study, there was no significant effect of rotation treatment on bean yields (Table 2). The overall highest yield was the 5-yr sustainable rotation (2,760 kg/ha) and the lowest yield was on the 4-yr sustainable rotation (2,054 kg/ha).

Table 2. Effect of rotation management on bean yield, Vauxhall, 2003.

Rotation	Previous Crop	Fall preparation	Spring Preparation	Yield, kg/ha
3 yr Conv.	Potatoes	Cultivate + crazy harrow	Triple K	2,407a
3 yr Sust.	Potatoes	Disc/crazy harrow. Fall rye cover	Direct seed into fall rye burnoff	2,108a
4 yr Conv.	Sugarbeets	Cultivate + crazy harrow	Triple K	2,109a
4 yr Sust.	Sugarbeets	Cultivate + crazy harrow	Direct seed	2,054a
5 yr Sust.	Wheat	Shred stubble	Direct seed into shredded stubble	2,760a
6 yr Sust.	Sugarbeets	Cultivate + crazy harrow	Direct seed	2,180a

*Means followed by the same letter are not significantly different from each other. (*P* = 0.05).

Table 3: Contrasts for bean yields, conventional vs. sustainable, 2003.

Characteristic	Conventional	Sustainable	P value
Yield(kg/ha)	2,258	2,276	0.95 *ns*
Height (cm)	41.8	46.4	0.02*
Sclerotinia, % plants	3.9	9.0	0.21 *ns*

*Significant at the 5% level.

Table 4: Contrast for bean yields, effect of preceding crop, 2003.

Characteristic	After potatoes	After Sugar Beet	P value
Yield(kg/ha)	2,257	2,114	0.61 *ns*
Height (cm)	45.3	44.0	0.50 *ns*
Sclerotinia, % plants	9.4	5.5	0.36 *ns*

There was no significant effect of row spacing (conventional = wide; sustainable = narrow) on bean yields in 2003 (Table 3) which was the same finding as 2002. In 2001, the wide-row beans (conventional) yielded significantly higher (by 43%) than narrow-row (sustainable) beans. Even though the narrow-row beans were seeded 6 d later in 2003, they were significantly taller (by 4.6 cm) than the wide-row beans.

Also, unlike the previous year (2002) where yields were significantly (by 53%) higher after sugar beets than after potatoes, there was no effect of preceding crop on bean yield in 2003 (Table 4).

Disease Ratings for Beans

Beans were assessed on 22 August 2003 for *Sclerotinia.* There was no significant rotation effect on the percent of plants infected. This varied from 2.3% on the 4 yr conventional rotation to 13.3% on the 3 yr sustainable rotation. The contrasts for bean disease ratings were non-significant (conventional vs. sustainable rotation and preceding crop (Tables 3 and 4). There was a trace to mild levels of bacterial blights on some of the plots on the narrow-row beans only.

Potato Yields

In 2003, potatoes (AC LR Russet Burbank) were grown on 24 plots (6 rotations x 4 reps). All potatoes were planted on May 2-3 (except Plots 71, 74 which were too wet and planted on May 22). Potatoes were harvested on September 16, 2003. All plots received two passes of a Triple K before planting. There was no significant difference between any of the 6 potato rotation treatments in 2003. Yields were over 70% higher than those of 2002 which had excessively wet conditions (average of 49.0 t/ha vs. 28.2 t/ha in 2002).

There was no negative effect of providing the full P requirement and partial N requirement of the potato crop with compost as the yield difference was non-significant (Table 5). There should be some residual nutrient release from the compost for subsequent crops. Additionally, the compost added organic matter which should benefit soil tilth.

Table 5. Effect of rotation management on potato yield, Vauxhall, 2003.

Rotation	Previous Crop	Fall preparation	Nutrient inputs, kg/ha	Total Yield*, t/ha
3 yr Conv.	Wheat	Plow,	112 N, 67 P, 67 K	46.2a**
3 yr Sust.	Wheat	Dammer diker	62 N, 28 P, 67 K 28 t/ha compost	51.8a
4 yr Conv.	Beans	Plow	112 N, 67 P, 67 K	47.5a
4 yr Sust.	Beans	Dammer diker	37 N, 0 P, 67 K 42 t/ha compost	50.0a
5 yr Sust.	Beans	Dammer diker	37 N, 0 P, 67 K 42 t/ha compost	48.6a
6 yr Sust.	Beans	Dammer diker	37 N, 0 P, 67 K 42 t/ha compost	49.7a

* Total yield = marketable + oversize yield. **Means followed by the same letter are not significantly different from each other. (P = 0.05).

There was no effect of rotation on any of the agronomic characteristics of potatoes (Table 6).

Table 6: Rotation effect on agronomic characteristics of potatoes, 2003.

Rotation	Julian date 50% Emergence	Vigour scale	Plant stand/36 m row	Marketable Yield t/ha	Oversize Yield t/ha	Undersize yield t/ha
3 yr Conv.	162a	4.3a	122a	31.8a	14.4a	3.4a
3 yr Sust.	159a	4.9a	125a	36.2a	15.6a	2.1a
4 yr Conv.	161a	4.4a	114a	33.9a	13.6a	3.1a
4 yr Sust.	161a	4.6a	123a	30.9a	19.1a	2.2a
5 yr Sust.	159a	4.6a	121a	30.8a	17.8a	2.3a
6 yr Sust.	160a	4.6a	125a	33.1a	16.6a	3.1a

*Means followed by the same letter are not significantly different from each other. (P = 0.05).

Similarly, all quality characteristics were non-significant for potatoes (Table 7). There was no significant rotation effect on specific gravity in 2003. Increased nitrogen levels can result in lower specific gravity. Specific gravity is a measure of dry matter content of the potato. A higher specific gravity (1.085-1.095) is desired for good texture, low oil absorption and improved production yield of french fries and chips. Rotation treatments that reduce specific gravity would be undesirable. Additionally, French fry colour, texture and colour uniformity was not significantly affected by rotation treatment.

Table 7. Quality and disease characteristics of potatoes, 2003.

Rotation	Marketable deformities t/ha	Oversize deformities t/ha	Oversize Hollow Heart*	Marketable Internal Necrosis*	Oversize Internal Necrosis	Specific Gravity	French Fry Colour USDA scale 1-7	French Fry Texture scale 1-4	French Fry Colour Uniformity scale 1-5
3 yr Conv.	1.7a	1.5a	0.00a	0.00a	0.00a	1.0830a	3.00a	3.50a	2.75a
3 yr Sust.	1.3a	0.8a	0.25a	0.25a	1.00a	1.0753a	3.25a	3.50a	3.25a
4 yr Conv.	1.0a	1.2a	0.00a	0.00a	0.00a	1.0783a	3.50a	3.25a	3.25a
4 yr Sust.	0.9a	2.4a	0.50a	0.25a	0.50a	1.0789a	3.13a	3.00a	3.00a
5 yr Sust.	1.4a	1.7a	0.25a	0.00a	0.00a	1.0729a	3.50a	3.25a	2.75a
6 yr Sust.	0.8a	1.9a	0.00a	0.00a	0.00a	1.0751a	3.25a	3.00a	2.75a

*Affected tubers/10 tuber sample.

No hollow heart was evident in marketable potatoes. Internal necrosis was evident at a very low level.

Contrast analysis for potato yield and quality showed that the general rotation effect (conventional vs. sustainable) was non-significant for all parameters in 2003 (Table 8) except specific gravity. The sustainable rotations had a significantly lower specific gravity than the conventional rotations (1.0756 vs. 1.0806). The preceding crop effect (potatoes after wheat vs. potatoes after beans) was non-significant for all parameters in 2003 (Table 9).

Table 8. Conventional vs. sustainable contrasts for potato parameters, 2003.

Characteristic	Units	Conventional	Sustainable	P value
Emergence	Julian days	161.4	159.5	0.22 *ns*
Vigour	Scale	4.34	4.67	0.25 *ns*
Stand count	36m row	118.1	124.0	0.07 *ns*
Yield (M + O)*	t/ha	46.8	50.0	0.56 *ns*
Marketable yield	t/ha	32.9	32.7	0.98 *ns*
Oversize yield	t/ha	14.0	17.3	0.28 *ns*
Undersize yield	t/ha	3.3	2.4	0.17 *ns*
M deformities	t/ha	1.4	1.1	0.64 *ns*
O deformities	t/ha	1.4	1.7	0.49 *ns*
M Hollow heart	% tubers	0	0	0.99 *ns*
O Hollow heart	% tubers	0	0.25	0.13 *ns*
M Internal necrosis	% tubers	0	0.13	0.32 *ns*
O internal necrosis	% tubers	0	0.38	0.36 *ns*
Specific Gravity	g	1.0806	1.0756	0.03 *
French Fry Colour	Scale 1-7	3.25	3.28	0.92 *ns*
French Fry Texture	Scale 1-4	3.38	3.19	0.35 *ns*
French Fry Col. Uniformity	Scale 1-5	3.00	2.94	0.81 *ns*

*M = marketable; O = oversize; * = significant at 5% level; ns = non-significant.

Table 9. Preceding crop contrasts for potato parameters, 2003.

Characteristic	Units	After beans	After wheat	P value
Emergence	Julian days	160.1	160.3	0.90 *ns*
Vigour	Scale	4.55	4.59	0.87 *ns*
Stand count	36m row	121.3	123.5	0.48 *ns*
Yield (M + O)*	t/ha	49.0	49.0	0.99 *ns*
Marketable yield	t/ha	32.2	34.0	0.62 *ns*
Oversize yield	t/ha	16.8	15.0	0.56 *ns*
Undersize yield	t/ha	2.7	2.8	0.90 *ns*
M deformities	t/ha	1.0	1.5	0.39 *ns*
O deformities	t/ha	1.8	1.1	0.18 *ns*
M Hollow heart	% tubers	0	0	0.99 *ns*
O Hollow heart	% tubers	1.9	1.3	0.69 *ns*
M Internal necrosis	% tubers	0.6	1.3	0.62 *ns*
O internal necrosis	% tubers	1.3	5.0	0.36 *ns*
Specific Gravity	G	1.0763	1.0792	0.20 *ns*
French Fry Colour	Scale 1-7	3.34	3.13	0.46 *ns*
French Fry Texture	Scale 1-4	3.13	3.50	0.07 *ns*
French Fry Col. Uniformity	Scale 1-5	2.94	3.00	0.81 *ns*

*M = marketable; O = oversize; ns = non-significant.

Sugar Beet Yields

Sugar beet was grown on 16 plots (4 rotations x 4 reps). Cultural details for sugar beet at Vauxhall in 2003 are shown in Table 10.

Table 10. Cultural details for sugar beet, Vauxhall 2003

Seedbed Preparation	**Following timothy**	
	Fall	Glyphosate application, Shred timothy stubble Plowed and disced 2x
	Spring	Disc and harrow 2x, Triple-K , Fertilize, Triple-K and Harrows 3x
	Following wheat	
	Fall	Shred wheat stubble, Disc and crazy harrow 2x
	Spring	Triple-K , Fertilize, Triple-K and Harrows 2x
Fertilizer Applied	After timothy - 200 lbs N/ac (broadcast)	
	After wheat - 100 lbs N/ac (broadcast)	
Planting Date	May 22 (delayed due to wet conditions)	
Seed/Row Spacing	6"/22"	
Herbicides	May 23	Nortron (0.8) – 7" band
(Liters of product/ac	June 5	Betamix (0.23) + Nortron (0.072) + UpBeet (6 g)
	June 12	Betamix (0.23) + Nortron (0.072) + UpBeet (6 g)
	July 8	Poast Ultra
Insecticides	May 23	Counter (7.2 lbs product/acre)
(Liters of product/ac	June 5	Decis (0.033) – 9" band
	June 12	Decis (0.033) – 9" band
Stand Count	September 29	
Harvest Date	September 29/30	

Yield and quality results for sugar beet are shown in Tables 11 and 12. There was no rotation effect for any of the measured variables. Extractable sugar was 62% higher and beet yield was 50% higher in 2003 compared with 2002, reflecting the favorable growing conditions in 2003.

Sugar beet stand was slightly higher than in previous years (average of 114 *vs.* 103 in 2002), but still below the ideal plant stand of 120 to 150 beets per 30.5 m of row length. There was a significantly higher stand in the 6-year rotation after timothy (128 plants/30.5 m) but this did not translate into higher yields (Table 11).

Table 11. Sugar beet yield, Vauxhall 2003.

Rotation	Previous crop	Extractable sugar		Sugar	Molasses loss	Yield	Stand
		t/ha	kg/t	%	%	t /ha	pl/100 ft
4-yr c	Wheat	9.78a	154.3a	17.71a	2.28a	63.8a	108b
4-yr s	Wheat	9.71a	151.1a	17.55a	2.44a	64.6a	106b
5-yr	Wheat	9.92a	160.1a	18.30a	2.29a	62.1a	112b
6-yr	Timothy	10.16a	159.5a	18.03a	2.08a	63.8a	128a

*Means followed by the same letter are not significantly different from each other. (*P* = 0.05).

Table 12. Sugar beet quality, Vauxhall 2003.

	Amino N	Na	K	Amino N	Na	K
Rotation	meq/100g fresh wt.			mg/kg fresh wt.		
4-yr c	0.98a	1.55a	5.67a	138a	356a	2218a
4-yr s	0.96a	1.47a	6.23a	134a	338a	2436a
5-yr	0.86a	1.26a	6.04a	121a	290a	2361a
6-yr	0.92a	1.19a	5.47a	128a	274a	2138a

*Means followed by the same letter are not significantly different from each other. (*P* = 0.05).

Table 13. Conventional vs. sustainable contrasts for sugar beet parameters, 2003.

Characteristic	Units	Conventional	Sustainable	P value
Extractable Sugar	t/ha	9.78	9.93	0.73 *ns*
Extractable sugar	kg/t	154.3	156.9	0.68 *ns*
Sugar concentration	%	17.71	17.96	0.57 *ns*
Molasses loss	%	2.28	2.27	0.97 *ns*
Yield	t/ha	63.8	63.5	0.91 *ns*
Plant stand	n/30.5 m	108	115	0.23 *ns*
Nitrogen concentration	mg/kg	138	128	0.69 *ns*
Sodium concentration	mg/kg	356	301	0.51 *ns*
Potassium concentration	mg/kg	2218	2312	0.36 *ns*

ns = non-significant.

Contrast analysis for sugar beet yield and quality revealed that the general rotation effect (conventional vs. sustainable) was non-significant for all parameters in 2003 (Table 13). The preceding crop effect (sugar beets after wheat vs. after beans) was non-significant for all parameters in 2003 (Table 14) except plant stand which was significantly higher after timothy than after wheat.

Table 14. Preceding crop contrasts for sugar beet parameters, 2003.

Characteristic	Units	After wheat	After timothy	P value
Extractable Sugar	t/ha	9.80	10.16	0.42 *ns*
Extractable sugar	kg/t	155.1	159.5	0.49 *ns*
Sugar concentration	%	17.85	18.03	0.69 *ns*
Molasses loss	%	2.34	2.08	0.19 *ns*
Yield	t/ha	63.5	63.8	0.93 *ns*
Plant stand	n/30.5 m	109	128	0.007 **
Nitrogen concentration	mg/kg	131	128	0.93 *ns*
Sodium concentration	mg/kg	328	274	0.52 *ns*
Potassium concentration	mg/kg	2338	2138	0.07 *ns*

** = significant at 1% level; ns = non-significant.

Wheat Yields

The soft white spring wheat variety AC Reed was used in 2003. In total there were 28 wheat plots on the study (7 rotations x 4 reps). Because of snowfall and wet conditions, seeding dates for wheat fell into 3 categories:

22 plots were seeded on May 3 before the rain/snow
6 plots (too wet on May 3) were seeded on May 21
5 of the 22 plots seeded on May 3 were re-seeded on May 23 due to severe crusting/low emergence.

The wheat was harvested on 25-26 September, 2003.

The continuous wheat (1 yr rotation) was significantly lower-yielding than all other rotation treatments (Table 15). On all treatments, except the continuous wheat, yields were higher than of those in 2002 (wet year). The continuing decline in wheat yields on the continuous wheat was due in large part to dense populations of barnyard grass [*Echinochloa crusgalli* (L.) Beauv]. This weed has become increasingly prevalent on the study plots, helped in part by excessively wet conditions in 2002 which it favours.

Table 15. Effect of rotation on wheat yield, Vauxhall, 2003.

Rotation	Previous Crop	Fall preparation	Yield, t/ha
3 yr Conv.	Beans	Cultivate + crazy harrow	5.30 a
3 yr Sust.	Beans	Disc + crazy harrow. Oat cover crop	5.51a
4 yr Conv.	Potatoes	Cultivate + crazy harrow	4.95 a
4 yr Sust.	Potatoes	Disc + crazy harrow, Oat cover crop	4.62 a
5 yr Sust.	Potatoes	Disc + crazy harrow, Oat cover crop	4.17 a
5 yr Sust.	Sugarbeet	Compost, Disc + crazy harrow, Oat cover crop	3.79 ab
1 yr Cont.	Wheat	Disc and crazy harrow	2.30 b

*Means followed by the same letter are not significantly different from each other ($P = 0.05$).

There was no significant effect of rotation on height of wheat (Table 16), although the trend was toward a short crop on the continuous wheat plots. The weed % denotes the prevalence of weed seeds in the harvest sample, prior to seed cleaning, and this indicates that the continuous wheat was significantly weedier than the other rotation treatments. On the continuous wheat treatment, the weed % increased from 13% to 20% from 2002 to 2003, denoting the increased weed pressure with lack of rotation. Also, the continuous wheat had a significantly higher incidence of take-all (*Gaeumannomyces graminis* var. *tritici*) than every other rotation treatment except the 5 yr wheat after potatoes (Table 16). The test weight (hectoliter weight) was also significantly lower on the continuous rotation. These findings point to the benefit or crop rotations and the downside of monoculture cropping.

Table 16. Agronomic, disease and quality characteristics of wheat, Vauxhall, 2003.

Rotation	Height (cm)	Weed %	Take All Rating	Test Weight Kg/hL
3 yr Conv.	78.0 a	4.5 b	1.19 b	71.7 a
3 yr Sust.	79.0 a	3.0 b	1.19 b	71.6 a
4 yr Conv.	76.3 a	2.4 b	1.24 b	71.8 a
4 yr Sust.	75.2 a	4.1 b	1.33 b	70.2 a
5 yr-P Sust.	73.3 a	4.0 b	1.37 ab	70.6 a
5 yr-Sb Sust.	73.8 a	7.2 b	1.25 b	70.1 a
1 yr Cont.	70.4 a	20.1 a	1.59 a	65.8 b

Rotation and preceding crop contrasts for wheat parameters were all non-significant in 2003 (Table 17). However, there was a trend of higher wheat yields following beans (5.4 t/ha) than potatoes (4.58 t/ha) with a P value of 0.15. Also, there was a trend toward higher take-all levels in wheat following potatoes compared to wheat following beans (P = 0.09).

Table 17. Contrasts for wheat parameters, Vauxhall 2003.

	Conventional vs Sustainable		
Characteristic	Conventional	Sustainable	P value
Test Wt. (kg/hL)	71.74	70.64	0.28 *ns*
Yield (t/ha)	5.12	4.52	0.26 *ns*
Height (cm)	77.1	75.3	0.42 *ns*
Weeds, %	3.4	4.6	0.70 *ns*
Take All (Rating)	1.22	1.28	0.34 *ns*
	After Beans vs After Potatoes		
Characteristic	After beans	After potatoes	P value
Test Wt. (kg/hL)	71.66	70.87	0.46 *ns*
Yield(t/ha)	5.40	4.58	0.15 *ns*
Height (cm)	78.5	74.9	0.14 *ns*
Weeds, %	3.8	3.5	0.93 *ns*
Take All (Rating)	1.19	1.31	0.09 *ns*

Oats and Timothy in the 6-yr Rotation

On the 6-yr rotation, the oat crop yielded an average of 6.8 t/ha when harvested as green feed on July 19, 2003. These plots were direct seeded to timothy on August 27, 2003.

First-cut timothy (July 7) in the first year phase of the 6-yr rotation yielded an average of 6.2

t/ha. First cut timothy (June 25) in the second year timothy phase yielded 5.3 t/ha. The second cut timothy (September 16) yielded an average of 7.6 t/ha for the first year crop and 4.9 t/ha for the second year crop. This gave a total timothy yield of 13.8 t/ha for the first year crop and 10.2 t/ha for the second year crop in 2003. According to the Timothy Production Handbook (Canadian Hay Association, 1999) irrigated timothy is capable of producing 11-13.5 t/ha. Our yields for the first year crop at Vauxhall were slightly above this level.

Insect Populations
Beneficial arthropods, such as carabid beetles, rove beetles and spiders, provide key ecoystem services including predation on potential pests and regulation of decomposers. Herbivores like wireworms (Elateridae) feed on plant roots and can become serious pests. Sustainable agricultural strategies should enhance populations and biodiversity of native predators to favour natural biological control and thereby reduce dependence on insecticides to control herbivores that reach pest levels.

Insect pit-fall traps were installed in June in the 3 yr rotations to monitor ground-dwelling insects. These were emptied at 2 week intervals until the end of August. The insects will be counted and classified into groups (beneficial, non-beneficial) over the coming months and these numbers will be examined in relation to rotation treatment.

One of our objectives is to monitor activity of selected soil arthropods in relation to crop type, rotation and management strategy.

Future work: Sampling with pitfall traps will continue in 2004. Further sorting to species level will be done as resources become available. It is hoped that an M.Sc. student will being working on this aspect of the project during the 2004 field season.

Wind Erosion Risk
Residue cover measurements to assess wind erosion risk were taken in 24-25 April 2003 by a manual rope method. This data will be assessed in the coming year.

Cover Crop Biomass
The fall rye cover crop planted after potatoes on the 3yr sustainable rotation on 10 October 2002 was assessed for biomass production in spring 2003. One plot (no. 72) was not seeded to fall rye as it was too wet in fall 2002. Samples were taken on 20 May 2003 from six 0.25 m^2 plots on each of the three plots. The biomass yields ranged from 0.95 to 1.18 Mg ha^{-1} with a mean of 1.11 Mg ha^{-1}. The fall rye was then sprayed with Roundup on May 20, 2003 ahead of direct seeding beans on May 28, 2003.

Weed Populations
Weeds were counted on a per species basis in each plot. 15 quadrants of 1/4 sq m each were counted per plot. This was done twice: once after emergence before application of an in-crop herbicide and again 4 weeks later. We now have four years of weed count data. Weed populations will be related to management information to examine if certain weeds build up with particular rotations.

The narrow row beans had particularly dense weed populations in 2003. Plans were made to streamline better weed management practices, especially for narrow row beans in 2004.

Soil Nutrient Samples
A full set of soil nutrient samples were taken in October 2002 for analysis of available N and

available P. This data was unavailable for the 2002 report. Samples were taken at the 0-7.5, 7.5-15, 15-30 and 30-60 cm depths on all 104 plots (Table 18). Using bulk density data, nutrient levels were estimated in kg/ha for the 0-60 cm soil depth.

Available N levels varied from only 3 kg/ha after the first year of timothy in the 6-yr rotation (Treatment 22) to 79 kg/ha after potatoes in the 6yr rotation (Treatment 26). It should be noted that since this was only the 3rd year of the study, timothy had not appeared prior to treatment 26 in 2002, hence the high level of N. The second lowest available N level was in the 2nd yr timothy crop in the 6 yr rotation (Treatment 23, 5 kg/ha) demonstrating the extraction of nitrogen by the deep-rooted timothy crop. Plots that were planted to sugar beets in 2002 (Treatments 9, 13, 18 and 24) also had low levels of available N varying from 10-19 kg/ha in the 0-60 cm depth (Table 18). Again, this shows the depletion of N under this crop.

Available P levels in the 0-60 cm depth varied from 163 kg/ha in Treatment 24 (after sugar beets in the 6 yr rotation) to 303 kg/ha in Treatment 16 (after potatoes in the 5 yr-rotation). Again levels of available P were low after 1st and 2nd year timothy crops (Treatments 22 and 23) in the 6 year rotation (180-189 kg/ha) and relatively low (163-240 kg/ha) after sugar beet (Treatments 9, 13, 18 and 24).

Table 18. Effect of rotation phase on soil available N and P, fall 2002.

Treatment	Rotation (2002 phase in bold)	Available N, kg/ha, 0-60 cm	Available P, kg/ha, 0-60 cm
1	**W**	38 abcde	177 e
2	(**P**-B-W)c	38 abcde	191 cde
3	(P-**B**-W)c	56 abc	269 abc
4	(P-B-**W**)c	37 abcde	180 de
5	(**P**-B-W)s	38 abcde	232 abcde
6	(P-**B**-W)s	35 abcde	223 abcde
7	(P-B-**W**)s	51 abcd	167 e
8	(**W**-SB-B-P)c	43 abcde	169 e
9	(W-**SB**-B-P)c	19 bcde	240 abcde
10	(W-SB-**B**-P)c	73 a	263 abcd
11	(W-SB-B-**P**)c	74 a	223 abcde
12	(**W**-SB-B-P)s	42 abcde	226 abcde
13	(W-**SB**-B-P)s	15 cde	165 e
14	(W-SB-**B**-P)s	48 abcde	176 e
15	(W-SB-B-**P**)s	44 abcde	289 ab
16	**P**-W-SB-W-B	54 abc	303 a
17	P-**W**-SB-W-B	54 abc	243 abcde
18	P-W-**SB**-W-B	10 cde	208 bcde
19	P-W-SB-**W**-B	67a	208 bcde
20	P-W-SB-W-**B**	36 abcde	247 abcde
21	**O(t)**-T-T-SB-B-P	48 abcde	235 abcde
22	O(t)-**T**-T-SB-B-P	3 e	189 cde
23	O(t)-T-**T**-SB-B-P	5 de	180 de
24	O(t)-T-T-**SB**-B-P	17 bcde	163 e
25	O(t)-T-T-SB-**B**-P	61 ab	205 bcde
26	O(t)-T-T-SB-B-**P**	79 a	199 cde

*Means followed by the same letter are not significantly different from each other. (*P* = 0.05).

Table 19 illustrates the effect of previous crop or phase of the rotation on levels of available N and P. At this early stage of the study, it may be that this parameter has a larger effect on soil nutrient levels than the actual rotation. Furthermore, crops with very different rooting patterns and nutrient extraction capability are being compared within rotations (e.g. timothy a deep-rooted grass vs. beans a very shallow-rooted legume). Table 19 confirms the extraction of N by timothy and sugar beet, leading to significantly lower available N levels than all other crops in the study. For available P, levels were generally high after all crops, the only difference being the lower level after timothy compared to potatoes. The high P levels in all plots of the study raise the issue of whether further P inputs should be limited until root zone levels are drawn down to lower values.

Table 19. Effect of previous crop on available N and P in soil (0-60 cm depth), fall 2002.

Previous Crop	No. plots	Avail. N, kg/ha, 0-60 cm	Avail. P, kg/ha 0-60 cm
Beans	24	52 a	231 ab
Potatoes	24	55 a	239 a
Sugar Beet	16	15 b	194 ab
Wheat	28	47 a	196 ab
Timothy	8	4 b	184 b
Oats	4	48 a	236 ab

*Means followed by the same letter are not significantly different from each other. ($P = 0.05$).

Soil Water Content

Neutron probe access tubes (2 per plot) were installed in all plots of the 4-yr rotation (32 plots) and were read for volumetric water content during the growing season (GH Dill, AAFRD).

Soil Microbiological Properties

A set of soil samples was taken on 18-19 July 2003 on selected rotation treatments to ascertain the impact of rotation on diversity of soil microorganisms (NZ Lupwayi, AAFC-Beaverlodge). Soil samples were collected at the flag-leaf stage of wheat growth. Plants were excavated from six random 0.5-m lengths of row from each plot. Loose soil was shaken off the roots, and the soil that adhered strongly to the roots was carefully brushed and kept as rhizosphere soil. Non-rhizosphere (bulk) soil (0-7.5 cm depth) was sampled from the middle of two adjacent wheat rows near each of the six locations per plot. The six bulk or rhizosphere samples from each plot were bulked, sieved through a 2-mm sieve and stored at 4 °C until required for analysis.

Soil microbial biomass was measured using the substrate-induced respiration (SIR) method, in which 300 mg of glucose was dissolved in 4.5 mL of water and added to 50 g air-dry soil. The soil was incubated in 1-L jars for 3 h at 22 °C, and the amount of CO_2 that accumulated in the head space was measured by gas chromatography. Microbial biomass C data for 2002 (July 10) are also presented (Table 20) since these were unavailable for the 2002 study report.

Functional bacterial diversity was evaluated by the Biolog™ method, which tests the ability of a microbial community to utilize different C substrates contained in a microplate. The procedure was adapted by colorimetrically standardizing inoculum densities in all (1 g) soil samples to about 103 cells mL^{-1}. Aliquots of 150 µL of the soil suspension were added to Biolog Ecoplates™ microplates containing 31 substrates and a water control. The plates were incubated at 28 °C without shaking. Optical densities in the wells were read with an enzyme-linked immunosorbent assay (ELISA) plate reader (at 590 nm) after 72 h of incubation. The optical density readings were corrected for the water controls in subsequent analyses. Negative readings after the correction were adjusted to zero.

On the basis of the patterns of utilization of the substrates by the bacteria in the soil suspensions, diversity was evaluated by calculating Shannon's diversity index (H'), substrate richness (S) and substrate evenness (E). H', which is a composite measure of S and E, was calculated as:

$$H' = -Spi (\ln pi)$$

where pi = Ratio of activity (i.e., optical density reading) on the ith substrate to the sum of activities on all substrates. S is the number of different substrates (out of 31) used by the bacterial community, i.e., equivalent to species richness in the soil, and was obtained by counting all positive optical density readings. E is a measure of the equitability of activities across all substrates, i.e., equivalent to how equally abundant the species are in the soil, and was calculated as:

$$E = H'/\ln S$$

Although there are no significant differences in most cases, there is a trend of sustainable > conventional, particularly in microbial biomass C (Table 20). Contrast analysis will be performed to check for differences between conventional vs. sustainable and the effect of current crop (e.g. beans vs. potatoes). Plots will be sampled again after 6 yr of cropping and similar measurements made to see if any particular rotation treatment favours microbial diversity.

Table 20. Effects of crop sequence and tillage management systems for irrigated land on soil microbial biomass and diversity at Vauxhall in 2002 and 2003.

Previous Crop	Microbial C, mg/kg soil		Diversity index, 2003[a]		
	2002	2003	S	E	H'
Bulk soil					
Beans, 3-yr conventional	134b[b]	425a[b]	18a	0.72a	2.10a
Beans in a 3-yr sustainable	159b	526a	21a	0.86a	2.61a
Potatoes in a 4-yr conventional	121b	369a	22a	0.73a	2.22a
Potatoes, in a 4-yr sustainable	156b	429a	19a	0.81a	2.34a
Potatoes, in a 5-yr sustainable	155b	402a	21a	0.81a	2.42a
Sugar beet, in a 5-yr sustainable	297a	464a	19a	0.77a	2.20a
Wheat, continuous	152b	386a	19a	0.76a	2.20a
Rhizosphere					
Beans, in a 3-yr conventional	274b	413a	20a	0.82a	2.47a
Beans, in a 3-yr sustainable	260b	489a	22a	0.84a	2.56a
Potatoes, in a 4-yr conventional	226b	493a	24a	0.84a	2.61a
Potatoes, in a 4-yr sustainable	305b	372a	24a	0.88a	2.80a
Potatoes, in a 5-yr sustainable	264b	453a	24a	0.84a	2.64a
Sugar beet, in a 5-yr sustainable	406a	407a	23a	0.83a	2.60a
Wheat, continuous	248b	485a	23a	0.82a	2.53a

[a]S = number of substrates utilized (n = 31), E = substrate evenness, and H' = Shannon's diversity index, which integrates S and E.
[b]Means followed by the same letter in a column (within a treatment category) are not significantly different at 5% significance level according to Least Significant Difference (LSD) test.

7. Plans for 2004

In spring 2003, plots will be seeded to beans, potatoes, sugar beets, soft wheat and oats/timothy, as dictated by the rotation sequence. The plot measurements carried out from 2000-2003 will be repeated in 2004. There are two more years of AARI funding left in this study. Funding expires on March 31, 2006.

9. Technology Transfer, 2003

Larney FJ, Blackshaw RE, Lynch DR, Mündel HH, Carcamo HA, Huang HC, Ellert BH, Smith EG, Pearson DC, Lupwayi NZ, Conner RL, Nitschelm JJ, Dill GH and McKenzie RH. 2003. Rotations. Pp. 63-81 *in* Annual Report, Agriculture and Agri-Food Canada/Alberta Pulse Growers. Submitted to Alberta Pulse Growers, Leduc, AB, January 2003.

Versions of this Annual Report was also submitted to the Potato Growers of Alberta and the Alberta Agricultural Research Institute.

Plot tour: FJ Larney, Irrigated rotation study at Vauxhall: Field Day, Potato Growers of Alberta, August 26, 2003.

Oral Presentations at Meetings/Conferences

Managing soil quality on your farm. F.J. Larney, Lamb-Weston Potato Grower Meeting, January 28, 2003, Taber, AB.

Composting: What can it offer the feedlot industry, the crop production industry and the oil and gas industry? FJ Larney, "Composting Matters!", Composting Council of Canada, Regional Composting Workshop, March 5, 2003, Red Deer, AB.

Vauxhall irrigated rotation study. FJ Larney, Alberta Pulse Growers, Zone 1 Meeting, March 26, 2003, Taber, AB.

Managing soil quality for potato production. FJ Larney, Ann. Meeting, Potato Growers of Alberta, November 12-14, 2003, Banff, AB

10. Executive Summary

This study continues to build after four years of cropping. In those four years we have seen one of the driest (2001) and the extreme wettest (2002) growing seasons at Vauxhall since records began in 1954 along with a relatively 'normal year' (2003). This challenge emphasizes the need for long-term rotational experiments such as these to capture a broad range of climatic variables. This only makes the results and associated conclusions more robust.

Agriculture and Agri-Food Canada
Research Branch

Agriculture et Agroalimentaire Canada
Direction générale de la recherche

Research Centre
5403 1st Ave. S.
Lethbridge, Alberta
CANADA T1J 4B1
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E-mail: larney@agr.gc.ca

610

Mr. Vern Warkentin
Executive Director
Potato Growers of Alberta
6008-46th Avenue
Taber, Alberta
T1G 2B1

RECEIVED MAR 1 0 2003

March 6, 2003

Re: Interim Report and Funding Renewal Request, Irrigated Rotation Study, Vauxhall

Dear Vern:

Further to our recent telephone conversation, I enclose a copy of the Interim Report from the Irrigated Rotation Study at Vauxhall for the 2002 growing season.

I wish to thank the Potato Growers of Alberta for their generous funding support for the project of $8,000 (April 1, 2001-March 31, 2002).

I request further funding for this project as follows:

April 1, 2003-March 31, 2004: $8,000

This funding will help maintain the project and ensure that it provides valuable information on sustainability issues for potato growers in southern Alberta. Funding provided by the Potato Growers of Alberta will be matched dollar for dollar with Agriculture and Agri-Food Canada's Matching Investment Initiative.

I trust that this funding request will be discussed at your upcoming Board Meeting. I look forward to hearing from you in the very near future.

Sincerely,

Frank Larney

F.J. Larney
Research Scientist,
Environmental Health Team

Vern recommended.
- carried we support
Mar 19/03
phoned Frank Mar 20/03

encl.

Canada

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POTATO GROWERS OF ALBERTA
6008 - 46 AVENUE
TABER, ALBERTA T1G 2B1
Tel: (403) 223-2262 Fax: (403) 223-2268

CANADIAN IMPERIAL BANK OF COMMERCE
5124-48TH AVE.,
TABER, AB T1G 1R9

00209

5/6/2003

PAY TO THE ORDER OF Receiver General of Canada

$ **8,000.00

Eight Thousand and 00/100** DOLL

Receiver General of Canada

PER

PER

MEMO

⑈002090⑈ ⑆00139⑉010⑆ 72⑉05317⑈

THIS DOCUMENT CONTAINS SECURITY FEATURES - SEE REVERSE | CE DOCUMENT CONTIENT DES CARACTÉRISTIQUES DE SÉCURITÉ - VOIR À L'ENDOS

POTATO GROWERS OF ALBERTA

Receiver General of Canada 5/6/2003 00209

Date	Type	Reference	Original Amt.	Balance Due	Discount	Payment
05/06/2003	Bill	SPA A04713	8,000.00	8,000.00		8,000.00
					Cheque Amount	8,000.00

Main Operating Accou Can$8,000.00

POTATO GROWERS OF ALBERTA

Receiver General of Canada 5/6/2003 00209

Date	Type	Reference	Original Amt.	Balance Due	Discount	Payment
05/06/2003	Bill	SPA A04713	8,000.00	8,000.00		8,000.00
					Cheque Amount	8,000.00

Main Operating Accou Can$8,000.00

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Research Branch | Direction générale de la recherche

Research Centre
P.O. Box 3000
Lethbridge, AB T1J 4B1
Telephone: (403) 327-4561
Facsimile: (403) 382-3156

April 17, 2003

Mr. V. Warkentin, Manager
Potato Growers of Alberta
6008 - 46 Avenue
Taber, AB
T1G 2B1

Fund Centre SPA No. A04713

RECEIVED APR 2 4 2003

Dear Vern:

Enclosed are two execution copies of the Collaborative Research and Development Agreement between the Minister of Agriculture and Agri-Food for Canada and Potato Growers of Alberta for Dr. Frank Larney's project entitled "Irrigated cropping systems for sustainable management".

You will notice that this latest template that is being used Branch-wide is much longer that the previous template, primarily because of standard boiler-plate clauses.

Would you please have these documents signed in blue ink by the appropriate authority, witnessed, and return both originals together with your cheque for $8,000 CDN made out to the Receiver General for Canada. I will have the documents dated and signed for the Minister and will return an original for your records.

Once we receive the cheque and signed agreement, the scientist can access Matching Investment Initiative (MII) funds approved for this project.

We are pleased to have PGA's support for this project.

$8000-
May 6, 2003
Ck# 2090

Yours truly,

Ken Lievers

Ken Lievers
Senior Commercialization Officer

:grt
Encl.
cc: G.H. Coulter, Marketing and Licensing Manager
F.J. Larney, Research Scientist

PAID

Canada

COLLABORATIVE RESEARCH AND DEVELOPMENT AGREEMENT

CRDA

Irrigated Cropping Systems for Sustainable Management

BETWEEN:

HER MAJESTY THE QUEEN IN RIGHT OF CANADA

AND:

Potato Growers of Alberta

TABLE OF CONTENTS

CRDA

Irrigated Cropping Systems for Sustainable Management

COLLABORATIVE RESEARCH AND DEVELOPMENT AGREEMENT

CRDA

Irrigated Cropping Systems for Sustainable Management

BETWEEN:

HER MAJESTY THE QUEEN IN RIGHT OF CANADA
as represented by the Minister of Agriculture and Agri-Food

("Canada")

AND:

Potato Growers of Alberta
a company incorporated under the Province of Alberta,
having its head office at
6008 - 46 Avenue, Taber, AB T1G 2B1

("Company")

INTRODUCTION

A. WHEREAS Canada and the Company intend to pool certain of their resources so as to collaborate in the execution of the ***Project*** for their mutual benefit;

B. Canada brings to the collaboration areas of soil conservation, weed science and integrated pest management;

C. The Company brings to the collaboration a vested interest in seeing its members employ input-saving and sustainable agronomic practices; and

D. The goals are to devise crop rotations that build soil quality and reduce herbicide, insecticide and fungicide inputs, and to ensure the long-term sustainability of irrigated cropping systems in southern Alberta.

NOW THEREFORE IN CONSIDERATION of the mutual covenants and obligations contained herein, the parties hereto covenant and agree as follows:

1 DEFINITIONS

In this ***Collaborative Agreement*** the following words and phrases have the meaning prescribed below:

1.1 Canada's Contribution
means the items and sums listed in Appendix "B" (Canada's Contribution) dedicated to the ***Project***;

1.2 Company's Contribution
means the items and sums listed in Appendix "C" (Company's Contribution) dedicated to the ***Project***;

1.3 Collaborative Agreement
means this agreement which includes attached appendices and refers to the whole of this agreement, not to any particular section or portion thereof, but does exclude the exhibits, which are attached for ease of reference only;

1.4 Execution Date
means the date of the last signature of the ***Collaborative Agreement***, as noted in Article 11 (Execution);

1.5 MII
means the Matching Investment Initiative, or any direct successor financial program that provides government financial funding directly tied to corporate financial contributions;

1.6 Party
means any one of the signatories to the ***Collaborative Agreement*** and ***Parties*** means both of them and their respective servants, agents, and employees; and

1.7 Project
means the research, development and evaluation project entitled "Irrigated cropping systems for sustainable management" as described in detail in Appendix "A" (Project Entitled "Irrigated cropping systems for sustainable management").

2 THE PROJECT

2.1 Particulars

Canada and the Company will jointly conduct the ***Project*** as further particularized in Appendix "A" (Project Entitled "Irrigated cropping systems for sustainable management"). In case of a conflict between the Appendix and the ***Collaborative Agreement*** proper, the ***Collaborative Agreement*** shall prevail.

2.2 No Guarantee of Outcome

The ***Parties*** acknowledge that the ***Project*** conducted within the scope of the ***Collaborative Agreement*** is an applied science endeavour with no guarantee of success, and is subject to the vicissitudes of science, nature, weather or financing. No ***Party*** shall be liable to any other ***Party*** for any failure to achieve the anticipated scientific mileposts due to the vicissitudes of science, nature, weather or financing.

2.2.1 For greater clarity, financing in this paragraph does not refer to the sums the ***Parties*** are obligated to pay or contribute pursuant to the ***Collaborative Agreement***.

2.3 Equipment

All equipment, material and supplies purchased by Canada with the prior approval (written, oral, tacit) of the Company, in connection with the ***Project*** by whatever funds, shall remain the property of Canada.

2.4 Access to Government Buildings and Property

The Company and its personnel shall abide by all orders and policies, including without limitation, those related to security, in force at Canada's establishments involved in the ***Project***, with respect to access to buildings and utilization of facilities or otherwise applicable. The Company shall not bring equipment, computers, cameras, computer, discs or materials into these establishments without the express knowledge and consent of Canada's authorized representative.

2.5 Her Majesty Not Obligated

Nothing in this ***Collaborative Agreement*** shall obligate any emanation of Her Majesty the Queen in Right of Canada to grant any required authorizations, permits, certificates or other regulatory permissions to the Company.

3 LOCATION AND DURATION

3.1 Term

The ***Project*** will be carried out at Canada's Lethbridge Research Centre's Vauxhall Sub-station, Province of Alberta, Canada, between the 1st day of April, 2003 and the 31st day of March, 2006, inclusive.

4 CONTRIBUTION BY CANADA

4.1 Contribution Details & Estimated Cash Value

Canada's Contribution is comprised of the items and sums listed in Appendix "B" (Canada's Contribution) and is estimated at CDN $562,500.

4.2 Matching Investment Initiative (MII)

Canada's Contribution may be funded in whole or in part by sums prescribed by and authorized under the ***MII***, and if this is the case, the ***MII*** support is indicated in Appendix "B". Canada's ***MII*** support shall not exceed the contributions funded entirely or solely by the Company. If ***Canada's Contribution*** is to be funded in whole or in part by ***MII*** support, Canada's obligation to fulfill ***Canada's Contribution*** shall be subject to the following conditions:

4.2.1 the ***Project*** and Company both qualify for and remain qualified for ***MII*** support throughout the term of the ***Collaborative Agreement***;

4.2.2 the ongoing availability of funding from the ***MII*** program throughout the term of the ***Collaborative Agreement***;

4.2.3 the continuation of the ***MII*** program throughout the term of the ***Collaborative Agreement***; and

4.2.4 the Company's complying with the prohibition against aggregating public funding as prescribed in paragraph 5.5 (No Stacking).

If any of the events contemplated under subparagraphs 4.2.1 to 4.2.4 inclusive occurs, then Canada shall have no obligation to provide, or to continue to provide any ***MII*** support, and Canada shall have no liability whatsoever for not providing such support.

4.3 Canada's Global Investment

The Company acknowledges that Canada's global investment in support of the ***Project*** and the attendant technologies includes without limitation, the following:

4.3.1 ***Canada's Contribution***, as described in paragraphs 4.1(Contribution Details & Estimated Cash Value) and 4.2 (Matching Investment Initiative);

4.3.2 the proportion of A-based money and facilities, both consumed during the ***Project*** and consumed in bringing the attendant technologies to the point of the ***Project***;

4.3.3 past ***MII*** or other support by Canada for the ***Project*** and the attendant technologies; and

4.3.4 income tax incentives for R & D claimed by the Company for the ***Project***.

4.4 No Direct Payments to Company

Canada's contribution to the ***Project*** will be in-kind. Canada shall not make any payments or in-kind contributions directly to the Company under the ***Collaborative Agreement***.

5 CONTRIBUTION BY THE COMPANY

5.1 Cash Contribution

The Company agrees to provide Canada with a cash contribution in the amount of CDN $8,000 per year (or CDN $24,000 in the aggregate), according to the schedule of payments specified in Appendix "C" (Company's Contribution), payable to the Receiver General for Canada, to be deposited in a Specified Purpose Account and used by Canada to fund the items as listed in Appendix "C" (Company's Contribution).

5.2 Dynamic Budget

In order to allow for sufficient flexibility in ensuring the optimal utilization of financial resources for the purposes of the ***Project***, the Company acknowledges that Canada may effect budgetary changes from one item listed in Appendices "B" and "C", to another item. However, it is understood that such budgetary changes, in and of themselves, will not result in the withdrawal of a part of the total sum deposited in the Specified Purpose Account for the ***Project***.

5.3 Interest & Uncommitted Funds

Within 6 (six) months of the termination pursuant to paragraph 7.1 (Unilateral Termination) or the expiration of the ***Collaborative Agreement***, any uncommitted funds provided by the Company (excluding any applicable interest) shall be returned to the Company. For greater clarity, committed funds includes, without limitation, funds designated for executory contracts (including employment contracts).

5.4 Non-Payment Fundamental Breach

Failure of the Company to meet the schedule of contributions specified in Appendix "C" (Company's Contribution) and make its in-kind contributions is a fundamental breach of the ***Collaborative Agreement***. The Company has no right of set-off against its contributions hereunder due to claims either under the ***Collaborative Agreement*** or under any other agreement with Canada.

5.5 No Stacking

The ***Company's Contribution***, which is to be matched by ***MII*** support, as set out in Appendix "C", shall not comprise or be funded by, directly or indirectly, derivatively or otherwise, applicable monies from any other federal or provincial or local government program.

6 INDEMNIFICATION

6.1 Company Indemnifies

The Company shall at its own cost indemnify, defend and save harmless Canada, and Canada's officers, employees, agents, and servants, from and against all claims whatsoever and whenever arising based on:

6.1.1 any disease or injury (including death) to the Company's personnel or any damage to the Company's property not attributable in whole or in part to Canada's negligence; or

6.1.2 any acts of negligence of the Company committed against Canada or a third party;

which arise directly or indirectly from the carrying out of the ***Project***.

6.2 Canada Indemnifies

Canada shall at its own cost indemnify, defend, and save harmless the Company, and the Company's officers, employees, agents, and servants, from and against all claims based on:

6.2.1 any disease or injury (including death) to Canada's personnel or any damage to Canada's property not attributable in whole or in part to the Company's negligence; or

6.2.2 any acts of negligence of Canada committed against the Company;

which arise from the carrying out of the ***Project,*** but excluding without limitation, claims for loss of profits, indirect, incidental / consequential damages, relational contractual economic loss arising directly or indirectly from any such claim accruing in law or equity.

6.3 Canada's Liability Cap

Canada's global liability to the Company under the ***Collaborative Agreement*** is limited in the aggregate to a sum equal to or less than the direct cash contribution actually received by Canada from the Company under Appendix "C" (Company's Contribution) for the time period commencing from the effective date of the ***Collaborative Agreement*** up to and including the date of judicial judgment or arbitrator's decision, as applicable.

6.4 No Action Against Employees

The Company acknowledges and is estopped from and waives any rights the Company might have to commence and prosecute any action whatsoever, regardless of form or grounds (including without limitation negligence, misrepresentation, breach of fiduciary duty, deceit) against any of Canada's employees, servants, agents or officers, arising out of any claimed breach of the ***Collaborative Agreement*** or transactions under the ***Collaborative Agreement*** or negotiations leading to the ***Collaborative Agreement***, or in any other way related to the ***Collaborative Agreement***. For greater clarity, the Company's remedies for any breach of or dispute under the ***Collaborative Agreement*** lie only against Canada, and only within the aforementioned parameters prescribed by the ***Collaborative Agreement***.

7 TERMINATION OF THE COLLABORATIVE AGREEMENT

7.1 Unilateral Termination

The ***Collaborative Agreement*** may be terminated by either ***Party*** at any time, upon sixty (60) days written notice to the other ***Party***.

7.2 Each Party's Duties on Termination

Subject to all applicable laws, including without limitation the Access to Information Act, upon termination pursuant to paragraph 7.1 (Unilateral Termination) or expiration of this ***Collaborative Agreement***:

7.2.1 each ***Party*** shall forthwith return to the other all papers, materials or other property of the other held by each ***Party*** for the purposes of carrying out this ***Collaborative Agreement***;

7.2.2 the Company shall pay any contribution funds owing during the sixty (60) day notice period plus any funds necessary to meet any commitments made prior to or during the notice period, but not owing until after the notice period; and

7.2.3 in addition, the Company shall pay 10% of the outstanding or unused funding (whichever is the greater) due from the date of notification of termination to the end of term to compensate Canada for administrative costs, lost opportunities and employment terminations, if the Company terminates the ***Collaborative Agreement*** pursuant to paragraph 7.1 (Unilateral Termination).

7.3 Surviving Obligations

All obligations of the ***Parties*** which expressly or by their nature survive termination or expiration, shall continue in full force and effect subsequent to and notwithstanding such termination or expiration, until they are satisfied or by their nature expire. For greater clarity, and without restricting the generality of the foregoing, the following provisions survive termination or expiration: Article 6 (Indemnification), and this paragraph.

8 INTENT AND INTERPRETATION

8.1 Entire Agreement

The ***Collaborative Agreement*** constitutes the entire agreement between the ***Parties*** pertaining to the subject matter hereof and supersedes all prior agreements, understandings, negotiations and discussions, or inducing pre-contractual representations, whether oral or written, of the ***Parties*** pertaining to such subject matter. There are no warranties, representations or other agreements between the ***Parties*** in connection with the subject matter hereof, except those specifically set out herein. The execution of the ***Collaborative Agreement*** has not been induced by, nor do any of the ***Parties*** rely upon or regard as material, any representations not included in this ***Collaborative Agreement***.

8.2 Waiver & Amendment

No supplement, modification or waiver of the ***Collaborative Agreement*** shall be binding unless executed in writing by the ***Parties***. No waiver of any of the provisions of the ***Collaborative Agreement*** shall be deemed or shall constitute a waiver of any other provision (whether or not similar) nor shall such waiver constitute a continuing waiver unless otherwise expressly provided.

8.3 Successors

The ***Collaborative Agreement*** shall enure to the benefit of, and be binding upon, the ***Parties*** and their respective heirs, executors, administrators, successors and permitted assigns.

8.4 Relationship

The ***Parties*** expressly disclaim any intention to any relationship not explicitly recognized in the ***Collaborative Agreement***. The ***Parties*** acknowledge that:

8.4.1 nothing contained in the ***Collaborative Agreement*** or any acts of any ***Party*** shall constitute or be deemed to constitute the ***Parties*** as partners, joint venturers, principal and agent, employer / employee, licensor / licensee or lessor / lessee in any way or for any purpose;

8.4.2 no ***Party*** has the authority to act for, or to assume any obligation or responsibility on behalf of, any other ***Party***; and

8.4.3 the relationship between the ***Parties*** is that of scientific collaborators, which relationship vests on applicable fiduciary or confidentiality obligations on the Company.

8.5 Recitals Accurate

The ***Parties*** acknowledge the truth and accuracy of the recitals.

8.6 No Adverse Presumption in Case of Ambiguity

There shall be no presumption that any ambiguity in the ***Collaborative Agreement*** be resolved in favour of either of the ***Parties***. For greater certainty, the *contra proferentum* rule shall not be applied in any interpretation of the ***Collaborative Agreement***.

8.7 Minister Not Fettered

Nothing in the ***Collaborative Agreement*** shall derogate from or otherwise fetter the ability of Canada to regulate, administer, manage or otherwise deal with agriculture and all attendant matters thereto.

8.8 Minister Complies with Law

Nothing in this ***Collaborative Agreement*** shall be interpreted so as to preclude Canada from disclosing information that Canada may be required or ordered to disclose under the Access to Information *Act*, or otherwise, pursuant to any applicable legislative requirement or any order of a court or other tribunal having jurisdiction.

8.9 Forum Conveniens & Applicable Laws

The ***Collaborative Agreement***, it validity, performance, discharge or construction shall be governed first by applicable Canadian Federal laws, and secondly by the laws of the Province of Alberta. The ***Parties*** hereby irrevocably and unconditionally attorn to the exclusive jurisdiction of the Courts of the Province of Alberta, and all courts competent to hear appeals therefrom. The ***Parties*** expressly exclude any conflict of laws' rules or principles which might refer disputes under the ***Collaborative Agreement*** to the courts of another jurisdiction. Despite the foregoing, if the ***Collaborative Agreement*** or any aspect of it becomes a subject of judicial proceedings in the United States of America, then firstly the Company irrevocably waives any and all rights it has to a trial by jury in the United States; and secondly, the Company agrees that the matter will be heard before a judge sitting alone, due to the nature and complexity of the ***Confidential Information*** and applicable laws.

8.10 Appendices

The attached Appendices "A" to "C" form an integral part of this ***Collaborative Agreement*** as fully as if it were set forth herein *in extenso*. In case of a conflict between the ***Collaborative Agreement*** proper and the Appendices, the ***Collaborative Agreement*** prevails.

8.11 Assignment

The ***Collaborative Agreement*** is personal to the Company and cannot be assigned, in whole or in part, including any interests, rights or obligations hereunder (however, such an assignment might be structured, including but not limited to: share sales, operation of law, merger, transfer, amalgamation or other direct or indirect manner), without the prior written consent of Canada, which consent may not be unreasonably withheld. The failure to obtain written consent shall render the assignment (or transfer) void. Any consent from Canada shall be effective only upon receipt by Canada of payment of five percent (5%) of all consideration involved in the assignment, transfer, sale, encumbrance or other transaction.

8.12 Control / Status of the Company

If the status of the Company changes in respect of ownership or control, technical or financial competence, location of the work place, loss of key staff or fundamental licenses or any other way which prejudices the ***Collaborative Agreement*** or the potential Canadian economic benefits therefrom, the Company shall promptly inform Canada, and Canada may terminate the ***Collaborative Agreement*** within ninety (90) days of such notification.

9 CROWN RIGHTS

9.1 No Bribes / No Share to Members of Parliament

The Company warrants that no bribe, gift, or other inducement has been paid, given, promised or offered to any Government official or employee for the obtaining of this ***Collaborative Agreement***. Pursuant to the Parliament of Canada Act, R.S.C. 1985, c. P-1, no member of the House of Commons or Senate will be admitted to any share or part of the ***Collaborative Agreement*** or to any benefit to arise from the ***Collaborative Agreement***.

9.2 Public Office Holders

It is a term of this ***Collaborative Agreement*** that no former public office holder, who is not in compliance with the post employment provisions of the *Conflict of Interest and Post-Employment Code for Public Office Holders* shall derive a direct benefit from this ***Collaborative Agreement***.

9.3 Serendipitous Intellectual Property

If any intellectual property, whatsoever, (including, but not limited to patents, trademarks, copyright, and trade secrets) arises from or is created in the course of the ***Project***, then ownership of such intellectual property immediately vests unconditionally in Canada. For greater clarity, the Company shall have no claim, encumbrance upon, or fetter on that intellectual property.

9.4 Prior Consent to Publication

The Company shall not publish (including advertise, endorse, or promote) or otherwise disclose any results arising out of the ***Project*** without the prior written consent of Canada, which consent shall not be unreasonably withheld.

10 NOTICES

10.1 Contact Individuals & Addresses & Numbers

Unless otherwise notified, the representatives of the ***Parties*** for the purpose of the ***Collaborative Agreement*** shall be:

For Canada:

Dr. F. J. Larney
Research Scientist
Agriculture and Agri-Food Canada
Lethbridge Research Centre
5403 1st Avenue South
Box 3000

Lethbridge, AB T1J 4B1
Telephone: (403) 317-2216
Facsimile: (403) 382-3156
Internet: larney@em.agr.ca
For the Company:

Mr. V. Warkentin, Manager
Potato Growers of Alberta
6008 - 46 Avenue
Taber, AB T1G 2B1
Telephone: (403) 223-2262
Facsimile: (403) 223-2268
Internet: vernw@potatonet.com

10.2 Mode of Service

All notices or other communications necessary under the ***Collaborative Agreement*** shall be in writing and shall be delivered personally; by courier; by facsimile; or any combination of the foregoing to the addresses and persons cited above or, subsequently, to such other persons or addresses or numbers as a ***Party*** may, from time to time, designate in writing to the other ***Party***.

10.3 Confirmation of Service

Any notice or communication shall be considered to have been received when personally served; when signed on the courier invoice; or when delivered according to the facsimile confirmation sheet.

11 EXECUTION

IN WITNESS WHEREOF this ***Collaborative Agreement*** has been executed by duly authorized representatives of the ***Parties***.

Executed in duplicate and effective this 2 day of October, 2003.

FOR HER MAJESTY THE QUEEN IN RIGHT OF CANADA:

(Witness)

Dr. John Culley
Program Director
Authorized to Sign Collaborative Agreement

Executed in duplicate and effective this 5th day of May, 2003.

FOR THE COMPANY:

(Witness)

(Signature)

W.J. WARKENTIN
(Name in block letters)

EXECUTIVE DIRECTOR
(Title)

Authorized to sign Collaborative Agreement

FINANCIAL CODE: A04713

12 APPENDIX A - Project

Project entitled "Irrigated Cropping Systems for Sustainable Management"

Problem/Opportunity Identified by the Industry:

Irrigation provides a greater opportunity for crop diversity than under dryland in southern Alberta. Irrigated crops are an extremely important part of southern Alberta's economy, supporting many on- and off-farm jobs. With the building of new potato processing plants in the Lethbridge/Taber area (McCain Foods, Lamb-Weston Inc.), there is a forecasted increase in potato acreage in the next 5-10 yrs. A detrimental way to achieve this would be to tighten up rotations and grow potatoes closer together. This is tempting in the short term for quick returns but will not be sustainable in the long-term because of soil, disease, weeds or pest problems. Rogers Sugar Ltd. at Taber has been recently upgraded to handle larger acreages of sugar beets. Also there is an increase in the acreages of pulse crops grown in the region. The industry saw that the time was ripe for a multi-disciplinary study looking at sustainable irrigated rotations in the area. Hence this study was initiated in 2000. Funding was previously provided under MII Project #00-179 for three years (April 1, 2000-March 31, 2003).

Objectives:

1. To devise crop rotations that build soil quality and reduce herbicide, insecticide and fungicide inputs.

2. To ensure the long-term sustainability of irrigated cropping systems in southern Alberta.

Impact/Benefits:

The study will examine the impact of conventional and sustainable rotations for potatoes, sugar beets, beans, soft wheat and timothy. The merits of each of six rotations will be judged using data on crop yield and quality, weed, disease and insect pressures and soil quality. The cornerstones of the sustainable rotations are: reduced tillage, cover cropping, use of compost and direct cutting rather than undercutting (for beans). This study will examine rotations varying in length from 3 to 6 years, with and without forage or cereal breaks. There may be short-term cash advantages toward increasing the intensity of potatoes or beans in rotations but there may be long-term detrimental effects on our soil resource in terms of reduction of soil quality and increased erosion risk. We need long-term rotation studies to fully understand the interactions that occur when crop choice and sequence are varied. Since the longest rotation is 6 years, the study needs to run for 12 years in order to complete two full cycles and gather meaningful results.

Work Plan, Commitments and Roles:

The following crop rotations were established in spring 2000 at the Vauxhall Sub-station of Agriculture and Agri-Food Canada. The 2003 growing season represents the 4th crop year of this study.

	Rotation	Management
1 Yr	W	Cont. wheat (baseline)
3 Yr	(P-B-W)c	Conventional
3 Yr	(P-B-W)s	Sustainable
4 Yr	(W-SB-B-P)c	Conventional
4 Yr	(W-SB-B-P)s	Sustainable
5 Yr	P-W-SB-W-B	Sustainable (cereal break)
6 Yr	O(T)-T-T-SB-B-P	Sustainable (forage-based)

W = wheat; P = potatoes; B = beans; SB = sugar beet; O = oats, T = timothy.

Each phase of each rotation was represented resulting in 26 treatments. These were replicated four times to give 104 plots. The plot dimensions were 10 x 18.3 m with a 2.1 m interplot area between each plot. The sustainable rotations are built around four specific management practices:

(1) direct seeding or reduced tillage where possible

(2) fall-seeded cover crops where possible

(3) composted cattle manure as a substitute for inorganic fertilizer

(4) straight cutting of solid seeded rather than undercutting of wide-row seeded beans.

2003-2004

- Measurements of wind erosion risk will be taken on plots in March 2003 (residue cover, surface roughness, aggregate size distribution) on plots that have had various residue management treatments in fall 2002.
- Seed potatoes, sugar beet, beans, soft wheat and oats as dictated by rotation sequence at study site in Vauxhall.
- Fertilize with recommended rates of N and P.
- Irrigate each crop on a timely basis according to water demand.

- Perform soil nutrient sampling, weed counts, mid-season biomass measurements, disease assessments, yield measurements and soil erodibility sampling.

- Apply sustainability treatments in fall (cover crop seeding, compost application, reduced tillage, direct cutting).

- Perform crop quality measurements including: hectolitre weight, protein content and hardness of the wheat; sugar content and quality of the sugar beet (Rogers Sugar Ltd.); protein content of beans; and dry matter, french fry colour and texture of the potatoes.

- Insects collected in the traps will be counted and identified into groups.

- Neutron probe soil moisture measurements will be collated with irrigation scheduling.

- Submit progress report in project renewal application.

2004-2006

- Continue as in 2003-04.

- We do not plan on changing any of the rotations, crop sequences within the rotations or treatments. This will allow soil quality parameters, weed, disease and insect levels to change which will in turn influence crop response. Yield differences between rotation treatments have shown up as early as 2001 which is only the second crop year in the study. As individual treatments start to build up different cropping histories, further differences should emerge.

- Other personnel with different expertise may be added to the study as it progresses. There is a lot of opportunity for research staff to superimpose individual studies on the rotation plots.

- Fall soil sampling (available N, available P, organic C, aggregate stability) on all rotations. The 6-yr rotation will have completed one full cycle and the 3-yr rotations, two full cycles.

- Annual reports will be submitted detailing the changes as the study progresses. A final report will be written after the 2005 growing season. This will represent results after one full cycle of the longest rotation (6-yr).

The role of the Potato Growers of Alberta is to provide partial funding for technical and summer student manpower to support the study.

Technology Transfer Plan: Results of the study have been and will be presented at grower meetings in both poster and oral formats (e.g. Annual Meetings of Potato Growers of Alberta, FarmTech

Conference, Agronomy Update). Also each summer, plot tours are hosted at Vauxhall for growers to see the crops in the various rotations and ask questions on rotation treatment effects. Additionally, each of the industry partners receives an annual report which they can pass along to growers or use in their magazines.

Budget:

a) Partner(s) Annual Contribution

	2003/04	2004/05	2005/06
Pay			
Salary (Rogers Sugar, inkind)[1]	10,500	10,750	11,000
Salary (PGA[2], SPA)	6,957	6,957	6,957
Salary (APG-P/Z1[3], SPA)	6,957	6,957	6,957
Non-Pay			
Operating (Rogers Sugar, inkind)[1]	10,500	10,750	11,000
Admin Costs (PGA, SPA)	1,043	1,043	1,043
Admin Costs (APG-P/Z1, SPA)	1,043	1,043	1,043
Total Industry	**$37,000**	**$37,500**	**$38,000**

[1]Manpower for land preparation, seeding, pesticide application, monitoring and harvest analyses; materials and supplies and travel); [2]PGA - Potato Growers of Alberta; [3]APG-P - Alberta Pulse Growers - Provincial; [4]APG-Z1: Alberta Pulse Growers (Zone 1).

b) AAFC MII Annual Contribution (all Theme 120)

	2003/04	2004/05	2005/06
Pay:			
Salary	24,664	25,035	25, 405
Benefits	4,933	5,007	5,081
Non-Pay Operating:			
M & S	500	500	500
Travel	300	300	300
Admin Costs	3,820	3,875	3,931
Sub-Total (MII Budget)	**34,217**	**34,717**	**35,217**
***Benefits** (20% of employees' salaries paid through industry cash funding)	2,783	2,783	2,783
Total AAFC Contribution	**$37,000**	**$37,500**	**$38,000**

13 APPENDIX B - Canada's Contribution

Note: In principle Canada's contribution is in kind only.

	2003/04	2004/05	2005/06
A-Base[1]	**150,000**	**150,000**	**150,000**
MII			
Pay:			
Salary	24,664	25,035	25, 405
Benefits	4,933	5,007	5,081
Non-Pay Operating:			
M & S	500	500	500
Travel	300	300	300
Admin Costs	3,820	3,875	3,931
Sub-Total (MII Budget)	34,217	34,717	35,217
Benefits (20% of employees' salaries paid through industry cash funding)	2,783	2,783	2,783
Total MII Contribution	**$37,000**	**$37,500**	**$38,000**
Total AAFC Contribution	**$187,000**	**$187,500**	**$188,000**

[1] Canada's contribution is valued at 0.4 scientific PY/year X $375,000/PY = $150,000.
Note: Additional support to the project is coming from Alberta Pulse Growers Commission.

14 APPENDIX C - Company's Contribution

	2003-04	2004-05	2005-06
Cash:			
Pay:			
Technical	$6,957	$6,957	$6,957
Administrative costs[1]	1,043	1,043	1,043
Total Cash	$8,000	$8,000	$8,000
TOTAL	**$8,000**	**$8,000**	**$8,000**

[1] Administrative costs are to be deposited into a special Specified Purpose Account reserved specifically for these costs.

Schedule of payments:	
On signing	$8,000
April 1, 2004	8,000
April 1, 2005	8,000
Total cash contribution	**$24,000**

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Irrigated Cropping Systems for Sustainable Management

Canada

Interim Report to Potato Growers of Alberta
March 6, 2003

1. **Project Title:** Irrigated Cropping Systems for Sustainable Management

2. **Researchers**: F.J. Larney, R.E. Blackshaw, D.R. Lynch, H.H. Mündel, H.A. Carcamo, H.C. Huang, B.H. Ellert, E.G. Smith, D.C. Pearson, Agriculture and Agri-Food Canada, Lethbridge Research Centre; N.Z. Lupwayi, Agriculture and Agri-Food Canada, Beaverlodge Research Farm; R.L. Conner, Agriculture and Agri-Food Canada, Morden Research Station, Manitoba; J.J. Nitschelm, Rogers Sugar Ltd., Taber; G.H. Dill, R.H. McKenzie, Alberta Agriculture Food & Rural Development, Lethbridge

3. **Funding Agencies:** Alberta Agricultural Research Institute (AARI)-Farming for the Future Research Funding Program, Potato Growers of Alberta, Alberta Pulse Growers Commission (Provincial and Zone 1); Rogers Sugar Ltd., AAFC-MII.

4. **Project Duration:** ongoing

5. **Objectives**: To devise crop sequences and tillage management systems for irrigated land that: 1) reduce soil erosion, enhance soil quality and ensure long-term sustainability; and (2) minimize weed and disease problems.

6. Summary of progress in 2002:

Experimental Treatments
The following crop rotations were established in spring 2000 at the Vauxhall Sub-station of Agriculture and Agri-Food Canada. The 2002 growing season represented the 3rd crop year of this study.

	Rotation	Management
1Yr	W	Cont. wheat (baseline)
3Yr	(P-B-W)c	Conventional
3Yr	(P-B-W)s	Sustainable
4Yr	(W-SB-B-P)c	Conventional
4Yr	(W-SB-B-P)s	Sustainable
5Yr	P-W-SB-W-B	Sustainable (cereal break)
6Yr	O(T)-T-T-SB-B-P	Sustainable (forage-based)

W = wheat; P = potatoes; B = beans; SB = sugar beet; O = oats, T = timothy.

Each phase of each rotation was represented resulting in 26 treatments. These were replicated four times to give 104 plots. The plot dimensions were 10 x 18.3 m with a 2.1 m interplot area between each plot.

The sustainable rotations are built around four specific management practices:
(1) direct seeding or reduced tillage where possible
(2) fall-seeded cover crops where possible
(3) composted cattle manure as a substitute for inorganic fertilizer
(4) straight cutting of solid seeded rather than undercutting of wide-row seeded beans

Weather Conditions

The 2002 growing season (Apr-Sep precipitation, 456 mm) was the wettest since records began at the Vauxhall sub-station in 1954 (Table 1). This followed 2001 which was one of the driest on record (Apr-Sep precipitation, 114 mm). June 2002 had over 3 times normal rainfall which caused severe flooding on the plot area, with the result that some plots were drowned out and subsequently written off. The 2002 growing season was also defined by cooler conditions, especially in the spring and fall. This delayed seeding and harvest. March 2002 was 10.8 °C and April 2.7 °C cooler than normal. September precipitation was twice normal which delayed harvesting.

Table 1. Vauxhall precipitation and air temperature and long-term mean (1954-present).

	Precipitation		Temperature	
	2002	Long Term Mean	2002	Long Term Mean
Jan	14.1	17.0	-5.5	-9.9
Feb	13.8	11.7	-1.9	-6
Mar	22.4	16.8	-12.3	-1.5
Apr	13	28.6	2.9	5.6
May	39.2	41.7	9.6	11.5
Jun	205.9	64.6	15.9	15.9
Jul	61.4	35.0	19.6	18.6
Aug	61.2	37.6	15.8	17.9
Sep	74.8	36.3	12.5	12.5
Oct	23.1	14.4	2.5	6.8
Nov	13.9	13.8	2.8	-1.4
Dec	7.4	15.2	-2.3	-7.1
Total	550.2	332.7		
Apr-Sep.	455.5	243.8	12.7	13.7

Bean Yields

Black beans (UI 406) were seeded on the conventional plots on May 18, 2002. The 3yr and 4 yr conventional rotations were seeded at a wide row spacing (60-cm). The sustainable rotations were seeded on May 27 with a John Deere 1560 no-till drill in a narrow-row spacing (20 cm). Bean harvest was hampered by the cool wet conditions in fall 2002. Beans were not harvested until October 17.

The 6-yr sustainable rotation narrow row beans were the highest yielding treatment and were significantly higher than 3 yr conventional and sustainable and the 5-yr rotation treatments (Table 2). However, there was no significant difference between the 6-yr narrow row beans and the 4-yr wide- or narrow-row beans.The lowest yielding treatment was the 3-yr narrow-row beans direct seeded into fall rye burnoff (926 kg ha^{-1}). However, it was not significantly different than the wide-row conventionally seeded beans in the 3 yr rotation (1149 kg ha^{-1}).

Table 2. Effect of rotation management on bean yield, Vauxhall, 2002.

Rotation	Previous Crop	Fall preparation	Spring Preparation	Yield, kg/ha
3 yr Conv.	Potatoes	Cultivate + crazy harrow	Triple K	1149bc
3 yr Sust.	Potatoes	Disc/crazy harrow. Fall rye cover	Direct seed into fall rye burnoff	926c
4 yr Conv.	Sugarbeets	Cultivate + crazy harrow	Triple K	1540ab
4 yr Sust.	Sugarbeets	Cultivate + crazy harrow	Direct seed	1525ab
5 yr Sust.	Wheat	Shred stubble	Direct seed into shredded stubble	1109bc
6 yr Sust.	Sugarbeets	Cultivate + crazy harrow	Direct seed	1705a

*Means followed by the same letter are not significantly different from each other. (*P* = 0.05).

Table 3: Contrasts for bean yields, conventional vs. sustainable.

Characteristic	Conventional	Sustainable	P value
Yield(kg/ha)	1344	1316	0.86 *NS*
Height (cm)	44.0	48.8	0.04*
Maturity (days)	117	110.5	<0.001***

Table 4: Contrast for bean yields, effect of preceding crop.

Characteristic	After potatoes	After Sugarbeet	P value
Yield(kg/ha)	1037	1590	0.003**
Height (cm)	44.5	49.3	0.06 *NS*
Maturity (days)	114.0	112.6	0.03*

There was no significant effect of row spacing on bean yields in 2002 (Table 3). This was different from the previous year when the wide-row beans (conventional) yielded significantly higher (43% higher) than narrow-row (sustainable) beans. Even though the narrow-row beans were seeded 9 d later, they were taller and matured faster than the wide-row beans.

Also, unlike the previous year, where there was no significant yield difference between bean yields after potatoes or sugar beets, the yields in 2002 where significantly higher after sugar beets than after potatoes (by 53%). Additionally beans after sugar beets matured significantly faster than those after potatoes.

Disease Ratings for Beans

Beans were rated for disease on August 21, 2002. The narrow-row beans had more plants infected with *Sclerotinia* than the wide row plants (narrow-row: 11.6% ± 3.7 SD vs. wide-row: 4.0%± 2.4 SD). There was no effect of row spacing on the incidence of bacterial blights in beans. Also, there did not appear to be a rotational effect on the incidence of either disease.

Potato Yields

In 2002, potatoes (AC LR Russet Burbank) were grown on six rotations. Potatoes were planted on May 10th and harvested on September 25th, 2002. All plots received two passes of a Triple

K before planting. There was no significant difference between any of the 6 potato rotation treatments in 2002. Yields were half to two-thirds of the 2001 crop which illustrates the effect of the excessively wet conditions.

There was no negative effect of providing the full P requirement and partial N requirement of the potato crop with compost as the yield difference was non-significant (Table 5). There should be some residual nutrient release from the compost for subsequent crops. Additionally, the compost added organic matter which should benefit soil tilth.

Table 5. Effect of rotation management on potato yield, Vauxhall, 2002.

Rotation	Previous Crop	Fall preparation	Nutrient inputs, kg/ha	Yield, t/ha
3 yr Conv.	Wheat	Plow,	112 N, 67 P, 67 K	27.2a*
3 yr Sust.	Wheat	Dammer diker	62 N, 28 P, 67 K 28 t/ha compost	33.1a
4 yr Conv.	Beans	Plow	112 N, 67 P, 67 K	29.1a
4 yr Sust.	Beans	Dammer diker	37 N, 0 P, 67 K 42 t/ha compost	22.8a
5 yr Sust.	Beans	Dammer diker	37 N, 0 P, 67 K 42 t/ha compost	30.7a
6 yr Sust.	Beans	Dammer diker	37 N, 0 P, 67 K 42 t/ha compost	26.2a

*Means followed by the same letter are not significantly different from each other. ($P = 0.05$).

There was no effect of rotation on any of the agronomic characteristics of potatoes (Table 6).

Table 6: Rotation effect on agronomic characteristics of potatoes, 2002

Rotation	Julian date 50% Emergence	Vigour scale 10-50	Stand count/36m row	Marketable Yield T/ha	Oversize Yield T/ha	Marketable yield/plant kg	Oversize yield/plant kg
3 yr Conv.	163a	18a	121a	24.26a	3.0a	0.66a	0.08a
3 yr Sust.	163a	23a	124a	28.61a	4.44a	0.78a	0.12a
4 yr Conv.	162a	24a	126a	24.44a	4.64a	0.65a	0.12a
4 yr Sust.	163a	21a	125a	19.63a	3.14a	0.52a	0.08a
5 yr Sust.	163a	20a	128a	28.02a	2.70a	0.74a	0.07a
6 yr Sust.	163a	23a	123a	23.40a	2.81a	0.62a	0.07a

*Means followed by the same letter are not significantly different from each other. ($P = 0.05$).

There was no significant rotation effect on specific gravity in 2002 (Table 7). Increased nitrogen levels can result in lower specific gravity. This may be due to the extra N fixed by the preceding bean crop. Specific gravity is a measure of dry matter content of the potato. A higher specific gravity (1.085-1.095) is desired for good texture, low oil absorption and improved production yield of french fries and chips. Rotation treatments that reduced specific gravity would be undesirable. AC LR Russet Burbank is considered to have a specific gravity suited to French fry production. Additionally, French fry colour, texture and colour uniformity was not significantly affected by rotation treatment.

Table 7. Quality and disease characteristics of potatoes, 2002.

Rotation	Marketable deformities T/ha	Oversize deformities T/ha	Marketable Hollow Heart*	Oversize Hollow Heart*	Specific Gravity	French Fry Colour USDA scale 1-7	French Fry Texture scale 1-4	French Fry Colour Uniformity scale 1-5
3 yr Conv.	7.95ab*	4.08a	0.25a	0.50a	1.0791a	2.50a	3.25a	3.00a
3 yr Sust.	4.34b	3.48a	0.00a	0.33a	1.0808a	2.63a	3.17a	3.30a
4 yr Conv.	16.00a	6.05a	0.25a	0.25a	1.0737a	3.00a	3.00a	3.00a
4 yr Sust.	11.70ab	5.94a	0.25a	1.25a	1.0778a	3.25a	3.00a	3.00a
5 yr Sust.	10.60ab	4.47a	0.09a	0.48a	1.0756a	2.50a	3.25a	3.00a
6 yr Sust.	14.54ab	5.05a	0.00a	0.50a	1.0745a	3.25a	3.00a	2.50a

*Affected tubers/10 tuber sample. No internal necrosis was evident.

Contrast analysis for potato yield and quality showed that the rotation effect was non-significant for all parameters in 2002 (Table 8) as was the preceding crop effect (Table 9).

Table 8. Conventional vs. sustainable contrasts for potato parameters, 2002.

Characteristic	Units	Conventional	Sustainable	P value
Emergence	Julian days	163.0	163.2	0.65 *NS*
Vigour	scale 10-50	20.9	21.8	0.76 *NS*
Stand count	36m row	123.6	125.1	0.56 *NS*
Yield (M + O)^	T/ha	28.15	28.19	0.99 *NS*
Marketable yield	T/ha	24.35	24.91	0.85 *NS*
Oversize yield	T/ha	3.81	3.27	0.51 *NS*
M Yield/plant	Kg	0.655	0.665	0.90 *NS*
O Yield/plant	Kg	0.102	0.087	0.48 *NS*
M deformities	T/ha	11.98	10.30	0.64 *NS*
O deformities	T/ha	5.07	4.74	0.85 *NS*
M Hollow heart	n/10 tubers	0.25	0.08	0.29 *NS*
O Hollow heart	n/10 tubers	0.37	0.64	0.43 *NS*
Specific Gravity	G	1.0764	1.0772	0.73 *NS*
French Fry Colour	Scale 1-7	2.75	3.66	0.54 *NS*
French Fry Texture	Scale 1-4	3.12	3.10	0.93 *NS*
French Fry Col. Uniformity	Scale 1-5	3.00	2.95	0.85 *NS*

M = marketable; O = oversize

Table 9. Preceding crop contrasts for potato parameters, 2002.

Characteristic	Units	After beans	After wheat	P value
Emergence	Julian days	163.1	163.4	0.57 *NS*
Vigour	scale 10-50	22.1	20.3	0.56 *NS*
Stand count	36m row	125.8	122.2	0.20 *NS*
Yield (M + O)^	T/ha	27.45	30.14	0.46 *NS*
Marketable yield	T/ha	23.87	26.44	0.43 *NS*
Oversize yield	T/ha	3.32	3.71	0.65 *NS*
M Yield/plant	kg	0.633	0.721	0.29 *NS*
O Yield/plant	kg	0.088	0.101	0.55 *NS*
M deformities	T/ha	13.21	6.15	0.08 *NS*
O deformities	T/ha	5.38	3.79	0.39 *NS*
M Hollow heart	n/10 tubers	0.15	0.12	0.77 *NS*
O Hollow heart	n/10 tubers	0.62	0.42	0.57 *NS*
Specific Gravity	g	1.0754	1.0800	0.09 *NS*
French Fry Colour	Scale 1-7	3.00	2.56	0.13 *NS*
French Fry Texture	Scale 1-4	3.06	3.21	0.55 *NS*
French Fry Col. Uniformity	Scale 1-5	2.87	3.15	0.32 *NS*

M = marketable; O = oversize

Sugar Beet Yields

Sugar beet (variety HH-811) was seeded on May 17th 2002. Seedbed preparation was shred stubble, disc and crazy harrow x2, broadcast fertilizer of 100lbs/ac N, 60lbs/ac P_2O_5 in the fall with one pass of a Triple K cultivator in the spring. The sugar beets were harvested on September 26th 2002.

There were no significant differences between the rotations for any of the yield characteristics measured (Table 10). The 5-yr rotation had significantly lower levels of Na compared to the other rotations (Table 11). The reasons for this are unclear at this time.

Table 10. Sugar beet yield results -Vauxhall 2002.

Treatment	Previous Crop	Extractable Sugar		Sugar	Molasses Loss	Beet Yield	Stand
		Kg/acre	kg/t	%	%	t /acre	pl/100 ft
4-yr c	Wheat	2373a	139.7a	16.81a	2.83a	17.01a	97a
4-yr s	Wheat	2569a	146.8a	17.05a	2.37a	17.47a	104a
5-yr	Wheat	2415a	148.2a	17.11a	2.29a	16.30a	102a
6-yr	Wheat*	2528a	141.3a	16.72a	2.59a	17.94a	107a

Table 11. Sugar beet quality results, Vauxhall 2002.

Treatment	Previous Crop	Amino N	Na	K	Amino N	Na	K
		meq/100g fresh wt.			Ppm fresh wt.		
4-yr c	Wheat	1.21a	2.88a	5.90a	169a	662a	2305a
4-yr s	Wheat	0.92a	2.04ab	5.45a	130a	469ab	2133a
5-yr	Wheat	0.83a	1.64b	5.67a	117a	376b	2218a
6-yr	Wheat*	1.11a	2.58ab	5.53a	155a	592ab	2162a

*In the 6 yr sustainable rotation wheat was substituted for 2nd yr Timothy in 2001

Wheat Yields

The soft white spring wheat variety AC Reed was seeded on May 14, 2002 at 120 lb/ac. The wheat was harvested on September 10, 2002.

The continuous wheat (1 yr rotation) was significantly lower-yielding than all other rotation treatments (Table 12). Yields were generally < 50% of those in 2001 due to excess moisture.

Table 12. Effect of rotation on wheat yield, Vauxhall, 2002.

Rotation	Previous Crop	Fall preparation	Spring Preparation	Yield, t/ha
3 yr Conv.	Beans	Cultivate + crazy harrow	112kg/haN, Triple K	3.37ab*
3 yr Sust.	Beans	Disc + crazy harrow. Oat cover crop	112kg/haN, Triple K	3.97a
4 yr Conv.	Potatoes	Cultivate + crazy harrow	112kg/haN, Triple K	3.90a
4 yr Sust.	Potatoes	Disc + crazy harrow, Oat cover crop	112kg/haN, Triple K	3.91a
5 yr Sust.	Potatoes	Disc + crazt harrow, Oat cover crop	112kg/haN, Triple K	3.11ab
5 yr Sust.	Sugarbeet	Compost, Disc + crazy harrow, Oat cover crop	112kg/haN, Triple K	3.59a
1 yr Cont.	Wheat	Disc and crazy harrow	112kg/haN, Triple K	2.51b

*Means followed by the same letter are not significantly different from each other ($P = 0.05$).

There was no significant effect of rotation on maturity or height of wheat (Table 13). The weed % denotes the proportion of weed seeds in the harvest sample, and this indicates that the continuous wheat was significantly weedier than the other rotation treatments. Also, the continuous wheat had a significantly higher incidence of take-all (*Gaeumannomyces graminis* var. *tritici*) than the 3 yr and 5 yr sustainable rotations. The test weight (hectoliter weight) was also lower on the continuous rotation. These findings point to the benefit or crop rotations and the downside of monoculture cropping.

Table 13. Agronomic, disease and quality characteristics of wheat, Vauxhall, 2002.

Rotation	Maturity - Days from seeding	Height (cm)	Weed %	Take All Rating	Test Weight Kg/hL
3 yr Conv.	114a	69.7a	4.97b	1.24ab	79.28a
3 yr Sust.	112a	70.3a	2.19b	1.12b	79.09a
4 yr Conv.	112a	71.2a	4.25b	1.20ab	78.87ab
4 yr Sust.	112a	71.4a	3.46b	1.19ab	78.515ab
5 yr-P Sust.	112a	68.0a	6.23b	1.11b	77.9bc
5 yr-Sb Sust.	113a	69.9a	5.65b	1.23ab	78.39abc
1 yr Cont.	112a	71.3a	12.98a	1.31a	77.21c

Rotation and preceding crop contrasts for wheat parameters were all non-significant in 2002 (Table 14).

Table 14. Contrasts for wheat parameters.

	Conventional vs Sustainable Contrasts		
Characteristic	Conventional	Sustainable	P value
Test Wt. (kg/hl)	79.06	78.48	0.13 *NS*
Yield(T/ha)	3.632	3.644	0.97 *NS*
Height (cm)	70.4	69.9	0.73 *NS*
Maturity (days)	112.88	112.25	0.44 *NS*
Weeds %	4.61	4.39	0.91 *NS*
Take All (Rating)	1.22	1.16	0.25 *NS*
	After Beans vs After Potatoes Contrasts		
Characteristic	After beans	After potatoes	P value
Test Wt. (kg/hl)	79.19	78.43	0.07 *NS*
Yield(T/ha)	3.668	3.639	0.92 *NS*
Height (cm)	70.0	70.2	0.91 *NS*
Maturity (days)	113.0	111.9	0.21 *NS*
Weeds %	3.58	4.66	0.60 *NS*
Take All (Rating)	1.18	1.17	0.76 *NS*

Oats and Timothy in the 6-yr Rotation

On the 6-yr rotation, the oat crop yielded an average of 7.00 t/ha when harvested as green feed on July 19th 2002. These plots were direct seeded to timothy on August 26, 2002. First cut timothy (June 28) in the first year timothy phase of the 6-yr rotation yielded an average of 7.36 t/ha whilst timothy in the second year yielded 7.73 t/ha. The second cut timothy (September 10) yielded an average of 4.67 t/ha for the first year crop and 4.04 t/ha for the second year crop. This gave a total timothy yield of 12.03 t/ha for the first year crop and 11.76 t/ha for the second year crop in 2002. According to the Timothy Production Handbook (Canadian Hay Association, 1999) irrigated timothy is capable of producing 11-13.5 t/ha. Our yields at Vauxhall were on the upper end of that scale.

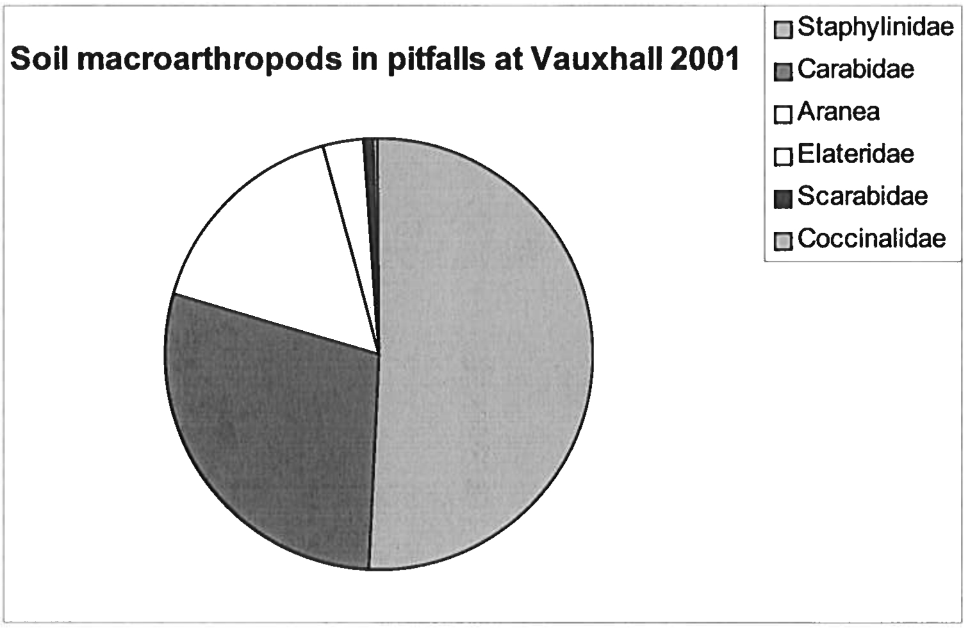
Insect Populations

Beneficial arthropods, such as carabid beetles, rove beetles and spiders, provide key ecoystem services including predation on potential pests and regulation of decomposers. Herbivores like wireworms (Elateridae) feed on plant roots and can become serious pests. Sustainable agricultural strategies should enhance populations and biodiversity of native predators to favour natural biological control and thereby reduce dependence on insecticides to control herbivores that reach pest levels.

Insect pit-fall traps were installed in June in the 3 yr rotations to monitor ground-dwelling insects. These were emptied at 2 week intervals until the end of August. The insects will be counted and classified into groups (beneficial, non-beneficial) over the coming months and these numbers will be examined in relation to rotation treatment.

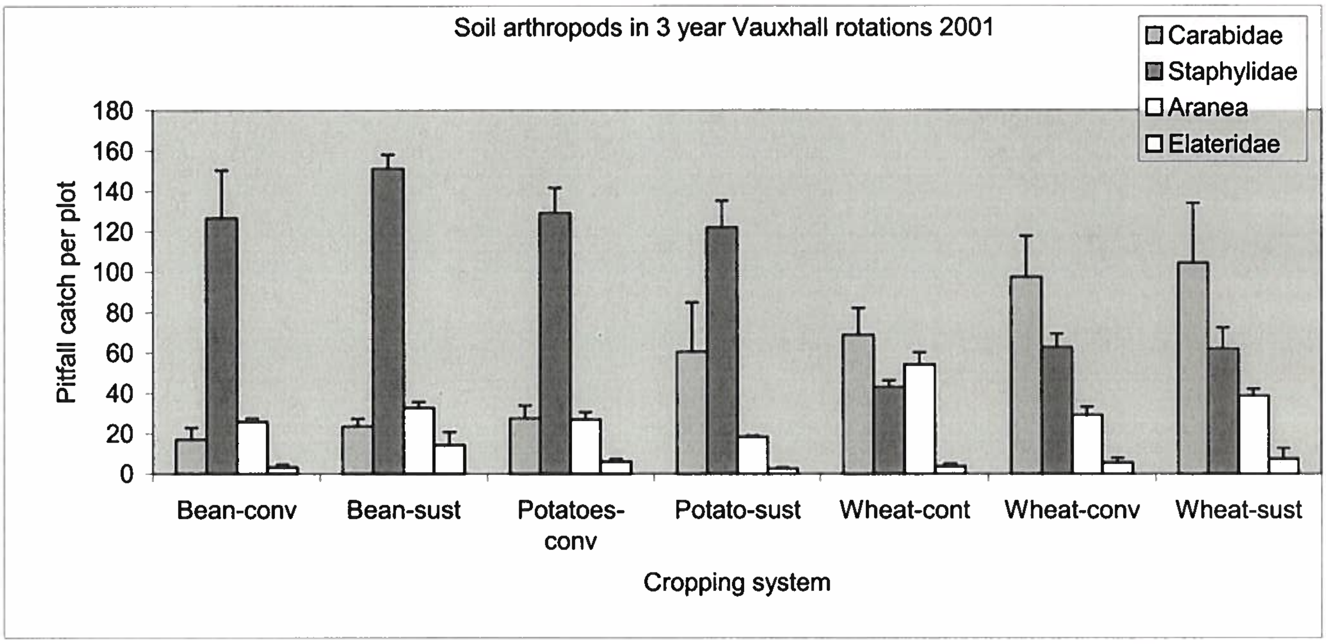
One of our objectives is to monitor activity of selected soil arthropods in relation to crop type, rotation and management strategy.

2001 Progress: Insects trapped during the 2001 growing season were enumerated in January 2002. Pitfall traps were dug in on June 7th, 2001 in plots allocated to treatments 1 to 7 (wheat, beans and potatoes, 3 year rotation and managed conventionally or sustainably). Two traps were placed near the middle of each plot but offset to one side to avoid the irrigation wheel. Undiluted propylene glycol (RV antifreeze) was added to fill about half the trap to kill and preserve the arthropods. Traps were collected every 2-3 weeks until August 16th.



Over 5500 arthropods were sorted from the pitfall catches. Staphylinid beetles and carabids were dominant (2788 and 1598, respectively), followed by spiders (905) and click beetles or elaterids (171); very few lady bird beetles, weevils and scarabs were found (see pie chart below). Wheat had far more carabids than beans or potatoes but this pattern was reversed for staphylinid beetles. Spider catches were highly variable and inconsistent among crops and management strategy but appear to respond positively to continuous wheat cropping. Staphylinids, and carabids to a lesser extent, may be enhanced by including beans to break a wheat rotation. Carabid beetles had consistently higher catches in plots managed sustainably in all crops and particularly in potatoes where carabid abundance was double in sustainable than in conventional plots. However, none of the differences were statistically significant ($p > 0.05$, LSD test). Elaterid beetles were not very abundant in the pitfalls but there were far more in the sustainable beans than in the conventional bean plots but variation among plots masked treatment effects. This group may be better sampled using manual sorting of soil quadrats or baits which is much more time consuming.

Future work: Sampling with pitfall traps will continue in 2002. Further sorting to species level will be done as resources become available.



Wind Erosion Risk
Residue cover measurements to assess wind erosion risk were taken in April 2002 by a manual rope method and by infra red reflectance. This data is being assessed and the two methods of measurement compared.

Cover Crop Biomass
The fall rye cover crop planted after potatoes on the 3yr sustainable rotation on 24 September 2001 was assessedor biomass production in spring 2002. Samples were taken on 14 May 2002 from six 0.25 m^2 plots on each of the four plots. The biomass yields ranged from 0.62 to 1.01 Mg ha^{-1} with a mean of 0.8 Mg ha^{-1}. The fall rye was then sprayed with Roundup on May 16/17, 2002 ahead of direct seeding beans on May 27, 2002.

Weed Populations
Weeds were counted on a per species basis in each plot. 15 quadrants of 1/4 sq m each were counted per plot. This was done twice: once after emergence before application of an in-crop herbicide and again 4 weeks later. We now have three years of weed count data. Weed populations will be related to management information to examine if certain weeds build up with particular rotations.

Soil Nutrient Samples
A full set of soil nutrient samples were taken in October 2002 for analysis of total C, total N, available N and available P. These were taken at the 0-7.5, 7.5-15, 15-30 and 30-60 cm depths on all 104 plots. They will be analyzed to use in deciding fertilizer applications in spring 2003.

Soil Water Content
Neutron probe access tubes (2 per plot) were installed in all plots of the 4-yr rotation (32 plots) and were read for volumetric water content during the growing season. This data was used for irrigation scheduling.

Soil Microbiological Properties
A set of soil samples was taken in July 2002 on selected rotation treatments to ascertain the impact of rotation on diversity of soil microorganisms.

Soil samples were collected at the flag-leaf stage of wheat growth in July 2002. Plants were excavated from six random 0.5-m lengths of row from each plot. Loose soil was shaken off the roots, and the soil that adhered strongly to the roots was carefully brushed and kept as rhizosphere soil. Non-rhizosphere (bulk) soil (0-7.5 cm depth) was sampled from the middle of two adjacent wheat rows near each of the six locations per plot. The six bulk or rhizosphere samples from each plot were bulked, sieved through a 2-mm sieve and stored at 4 °C until required for analysis.

Soil microbial biomass was measured using the substrate-induced respiration (SIR) method, in which 300 mg of glucose was dissolved in 4.5 mL of water and added to 50 g air-dry soil. The soil was incubated in 1-L jars for 3 h at 22 °C, and the amount of CO_2 that accumulated in the head space was measured by gas chromatography.

Functional bacterial diversity was evaluated by the Biolog™ method, which tests the ability of a microbial community to utilize different C substrates contained in a microplate. The procedure was adapted by colorimetrically standardizing inoculum densities in all (1 g) soil samples to about 103 cells mL^{-1}. Aliquots of 150 µL of the soil suspension were added to Biolog Ecoplates™ microplates containing 31 substrates and a water control. The plates were incubated at 28 °C without shaking. Optical densities in the wells were read with an enzyme-linked immunosorbent assay (ELISA) plate reader (at 590 nm) after 72 h of incubation. The optical density readings were corrected for the water controls in subsequent analyses. Negative readings after the correction were adjusted to zero.

On the basis of the patterns of utilization of the substrates by the bacteria in the soil suspensions, diversity was evaluated by calculating Shannon's diversity index (H'), substrate richness (S) and substrate evenness (E). H', which is a composite measure of S and E, was calculated as:

$$H' = -Spi (\ln pi)$$

where pi = Ratio of activity (i.e., optical density reading) on the ith substrate to the sum of activities on all substrates. S is the number of different substrates (out of 31) used by the bacterial community, i.e., equivalent to species richness in the soil, and was obtained by counting all positive optical density readings. E is a measure of the equitability of activities across all substrates, i.e., equivalent to how equally abundant the species are in the soil, and was calculated as:

$$E = H'/\ln S$$

Results from the microbial diversity (Table 15) showed that the effect of rotation had not become manifest in the study after only 3 yr of cropping. Plots will be sampled again after 6 yr of cropping and similar measurements made to see if any particular rotation treatment favours microbial diversity.

Table 15. Effects of crop sequence and tillage management systems for irrigated land on soil microbial biomass and diversity at Vauxhall, July 10, 2002.

Previous crop	Diversity index[a]		
	S	E	H'
Bulk soil			
Beans, in a 3-yr conventional rotation	24a[a]	0.73a	2.33a
Beans, in a 3-yr sustainable rotation	24a	0.81a	2.56a
Potatoes, in a 4-yr conventional rotation	19a	0.73a	2.11a
Potatoes, in a 4-yr sustainable rotation	25a	0.72a	2.33a
Potatoes, in a 5-yr sustainable rotation	26a	0.79a	2.58a
Sugar beet, in a 5-yr sustainable rotation	25a	0.76a	2.45a
Wheat, continuous	24a	0.78a	2.44a
Rhizosphere			
Beans, in a 3-yr conventional rotation	25a	0.84a	2.70a
Beans, in a 3-yr sustainable rotation	22a	0.84a	2.59a
Potatoes, in a 4-yr conventional rotation	26a	0.82a	2.68a
Potatoes, in a 4-yr sustainable rotation	27a	0.84a	2.76a
Potatoes, in a 5-yr sustainable rotation	26a	0.82a	2.68a
Sugar beet, in a 5-yr sustainable rotation	27a	0.86a	2.81a
Wheat, continuous	26a	0.78a	2.52a

[a]S = number of substrates utilized (out of 31), E = substrate evenness, and H' = Shannon's diversity index, which integrates S and E.
[b]Means followed by the same letter in a column (within a treatment category) are not significantly different at 5% significance level according to Least Significant Difference (LSD) test.

7. Plans for 2003

Measurements of wind erosion risk will be taken on plots in March 2003 (residue cover, surface roughness, aggregate size distribution). In spring 2003, plots will be seeded to beans, potatoes, sugar beets, soft wheat and oats/timothy, as dictated by the rotation sequence. The plot measurements carried out from 2000-2002 will be repeated in 2003.

9. Technology Transfer, 2002

Larney FJ, Blackshaw RE, Lynch DR, Mündel HH, Carcamo HA, Huang HC, Ellert BH, Smith EG, Pearson DC, Conner RL, Nitschelm JJ, Dill GH and McKenzie RH. 2002. Rotations. Pp. 74-84 *in* Annual Report, Agriculture and Agri-Food Canada/Alberta Pulse Growers. Submitted to Alberta Pulse Growers, Leduc, AB, January 2002.

Larney FJ, Blackshaw RE, Lynch DR, Mündel HH, Nitschelm JJ, Dill GH, Carcamo HA, Huang HC and Pearson DC. 2002. A new irrigated rotation for sustainable management. P. 128, Poster Abs. FarmTech 2002, January 30-February 1, 2002, Red Deer, AB.

Blackshaw RE and Larney FJ. 2002. Long-term studies test drive sustainable farming methods. LRC Report, March 6, 2002.

Larney FJ, Blackshaw RE, Lynch DR, Mündel HH, Carcamo HA, Huang HC, Ellert BH, Smith EG, Pearson DC, Conner RL, Nitschelm JJ, Dill GH and McKenzie RH. 2002. Rotations. Annual Report. Submitted to Potato Growers of Alberta, Taber, AB, March 8, 2002. 10 pp.

Plot tour presentations to:
Australian potato growers (hosted by McCains), Vauxhall, July 30, 2002.
Potato Growers of Alberta, field tour: Vauxhall, August 27, 2002.

Poster presentations:
Pearson, DC and Larney FJ. 2002. An irrigated rotation study for sustainable management of potatoes. Ann. Meeting, Potato Growers of Alberta, November 13-15, 2002, Red Deer, AB.

10. Executive Summary

This study is starting to build after three years of cropping. IN those three years we have seen one of the driest and the extreme wettest growing seasons at Vauxhall since records began in 1954. This challenge emphasizes the need for long-term rotational experiments such as these to capture a broad range of climatic variables. This only makes the results and associated conclusions more robust.