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Canada

Agricultural practices to improve input and resource use efficiency in cropping systems

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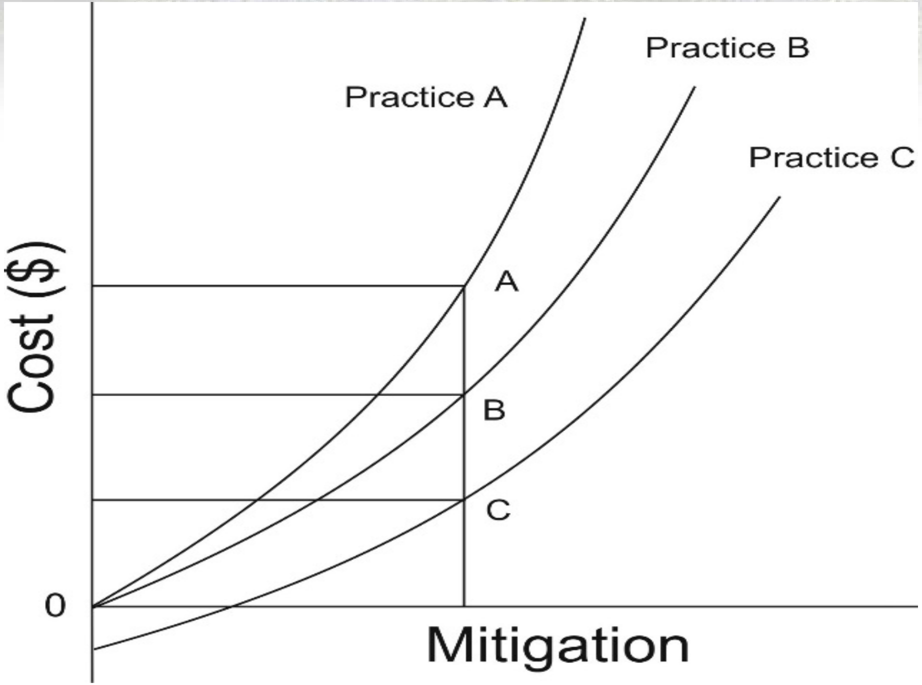
Background for resource use efficiency

► Intensive agricultural production systems rely on the heavy use of external resources including high rates of fertilizer and pesticides, and intensive use of machinery and fossil fuel energy.

►The intensive use of such inputs can negatively impact public health and the environment including soil and water quality, and also affect farm economics.

► Agricultural systems can reduce resource consumption and environmental impacts through the adoption of new technologies and alternative management practices.

Costs of mitigating an undesirable output for three technologies



Objective

- To use data from various projects across western Canada to evaluate conservation land, nutrient, and crop management practices that improve resource use efficiency in agricultural production.

Effect of legume in crop rotations

Average annual net revenue as affected by preceding crop over seven sites in western Canada from 2009 to 2011.

Preceding crop	Net revenue ($ ha^{-1})		Energy output /input ratio	
	C	PC-C-B	C	PC-C-B
Canola	240c	188b	6.21c	6.34cd
Faba bean as GM	586a	76c	8.61a	5.30e
Faba bean	373b	256a	7.06b	6.65c
Field pea	425b	284a	7.07b	7.27b
Lentil	442b	292a	7.06b	7.79a
Wheat	348b	169b	6.78bc	6.17d

Means followed by the same letter in a column are not significant ($p>0.05$).

Output to input ratio = for every unit of energy used, how much energy output were harvested.

Effect of legume in crop rotations on Energy use efficiency

Rotation group	Crop rotation[1]	Tillage[1]	Energy output /input ratio
1	C-W-B-B[2]	CT	6.60
	C-B-FP-W[2]	CT	7.24
2	Ws-Fx-C[3]	ZT	6.66
	Ww-FP-C[3]	ZT	7.97
3	Ws-Ws-Fx-Ww[4]	MT	5.13
	Ws-Fx-Ww-FP[4]	MT	6.16

[1]C: Canola, W: Wheat, B: Barley, FP: Field peas, Ws: Spring wheat, Fx: Flax, Ww: Winter wheat, CT: Conventional tillage, ZT: Zero tillage, MT: Minimum tillage, F: Full fertilizer and pesticide applied (100% of recommended rate), R: Reduced fertilizer and pesticide applied (50% of recommended rate). [2] Nagy et al. (2000). [3] Khakbazan et al. (2004). [4] Zentner et al. (2004).

- Legume preceding crops (lentil or field pea) grown for seed provided greater economic returns and energy use efficiency (EUE).

Effect of N fertilizer and Manure /Compost Management

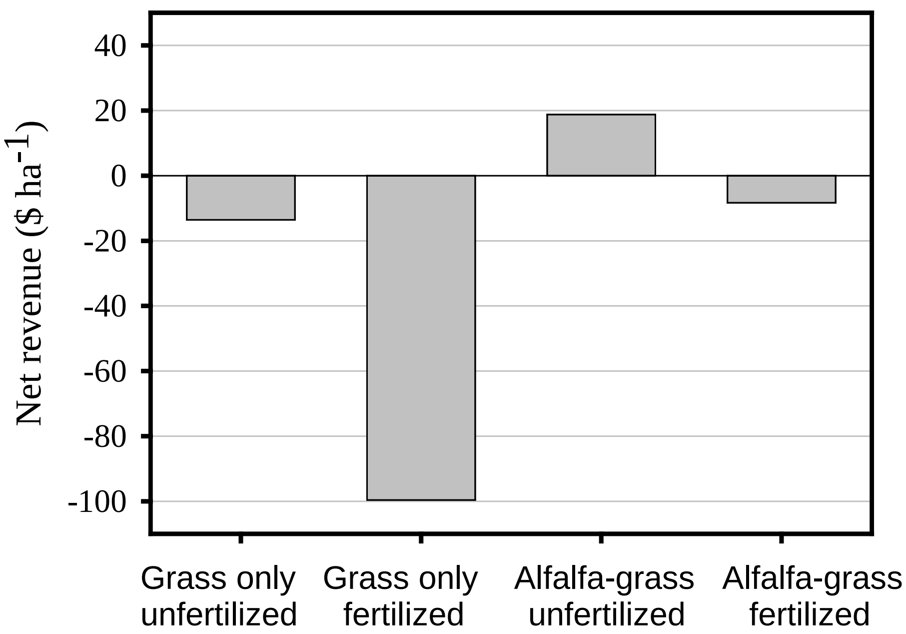
Annual net revenue and energy use efficiency of cropping systems as affected by nitrogen application rates over seven locations in western Canada from 2009 to 2011

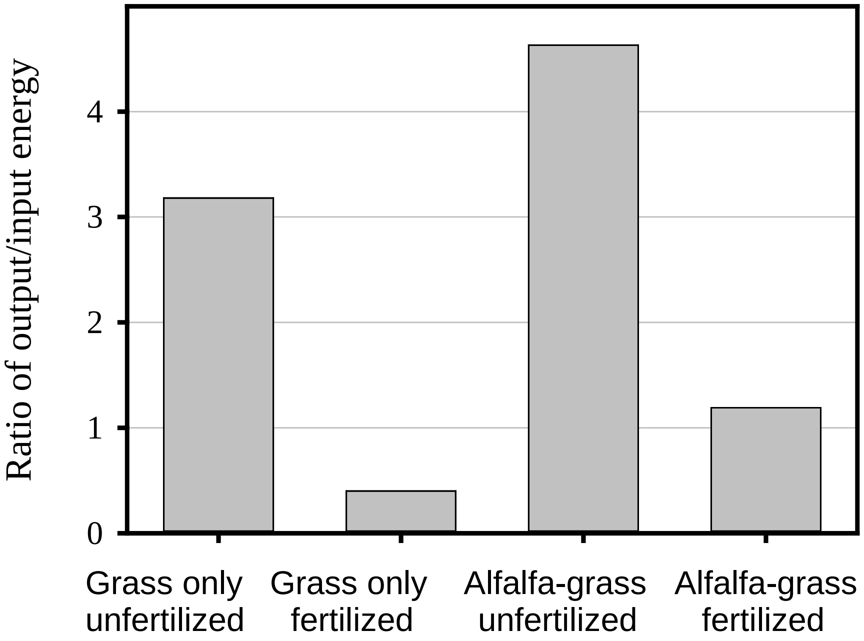
Nitrogen rate (kg ha^{-1})	Net revenue ($ ha^{-1})	Energy output /input ratio
	PC-C-B	PC-C-B
0	143	7.85a
30	169	6.99b
60	213	6.55c
90	217	5.95d
120	212	5.46e

Cropping sequence from 2009 to 2011 was preceding crops (PC)-canola (C)-barley (B).

In Western Canada, inorganic fertilizer and fuel usage can account for > 80% of the non-renewable energy expended in crop management (Zentner et al. 2004)

Net Revenue and Efficiency of Non-Renewable Energy Use in Pasture (10 Year Average Based on 2007 Fertilizer and Input Prices)





- N applied could be reduced below maximum without diminishing yield or profitability and without diminishing energy output or energy use efficiency.

Comparisons of net revenue and energy use efficiency of potato over 12-years (2000-2011) as affected by CONV and CONS practices

Contrast between management practice	Net revenue (\$ ha^{-1})		Energy output/input ratio	Potato yield harvested per GJ input (kg GJ^{-1})
	Compost= \$27 Mg^{-1}	Compost= \$15 Mg^{-1}		
CONV	1648	1648	2.79	827
CONS	1409	1844	2.93	863
P-Value	0.0451	0.0926	0.0147	0.0155

3-yr CONV = 3-yr rotation (potato-bean-wheat) under conventional crop management practice;
3-yr CONS = 3-yr rotation (potato-bean-wheat) under conservation crop management practice;
4-yr CONV = 4-yr rotation (wheat-sugar beet-bean-potato) under conventional crop management practice;
4-yr CONS = 4-yr rotation (wheat-sugar beet-bean-potato) under conservation crop management practice;
5-yr CONS = 5-yr rotation (potato-wheat-sugar beet-wheat-bean) under conservation crop management practice;
6-yr CONS = 6-yr rotation (oat(timothy)-timothy-timothy-sugar beet-bean-potato) under conservation crop management practice.

- Averaged over 12-yr, potato yields for 4-yr CONV rotations (potato–wheat–beet–bean) were lower than those for CONS systems. However, the decreased costs associated with not using compost in 4-yr CONV offset the loss in yield, thereby resulting in an overall net income higher than that of CONS systems.
- CONS can be used as a means of reducing the reliance on non-renewable energy inputs and improving overall EUE of potato production.

Precision farming

- Analytics show considerable variability in crop yield and response to N fertilizer between fields and farms
- This variability is attributed to different management, soil series and terrain attributes in the fields.
- The importance of recommendations by field is significant.

2014 Results for variable management of N fertilizer for canola across western Canada

- 2014 preliminary results showed variable management of N fertilizer had positive effects in some fields but were not consistent.
- Soil test data did not account for responses to N fertilizer in some fields, additional research on yield response may be merited.

Results - Wheat

- Zone (spatial) and time (temporal) effects:

Yield = a*Nrate + b + λ*Zone + θ*Time

- Quadratic was also tested but linear fitted better than quadratic

Year	Zone	Parameter	Estimate	StdErr	Probt	t-ratio
		a	13.58	0.98	0.00	
		b	1781.35	87.06	0.00	
	1		49.90	16.42		3.04
	2		9.36	16.57		0.56
	3		-38.02	26.94		-1.41
	4		-262.01	51.34		-5.10
1991			-156.46	57.72		-2.71
1992			260.87	54.80		4.76
1993			-934.07	51.05		-18.30
1994			-616.78	58.74		-10.50
1995			-636.32	56.65		-11.23
1996			-241.86	51.09		-4.73
1997			-382.85	65.80		-5.82
1998			-42.05	67.41		-0.62
1999			-195.30	57.31		-3.41
2000			370.13	61.01		6.07
2001			-352.30	65.45		-5.38
2002			-152.59	69.18		-2.21
2003			682.41	69.77		9.78
2004			418.08	67.95		6.15
2005			-669.94	74.11		-9.04
2006			-45.48	62.25		-0.73
2007			290.20	82.21		3.53
2008			707.09	67.73		10.44
2009			722.54	74.74		9.67
2010			564.41	61.29		9.21
2011			-577.62	66.85		-8.64
2012			527.33	59.31		8.89
2013			359.31	70.77		5.08
2014			865.49	57.95		14.93

Results - Canola

- Zone (spatial) and time (temporal) effects:

Yield = a*Nrate + b + λ*Zone + θ*Time

- Quadratic was also tested but linear fitted better than quadratic

Year	Zone	Parameter	Estimate	StdErr	Probt	t-ratio
		a	5.37	0.50	0.00	
		b	1483.82	54.44	0.00	
	1		70.94	11.38		6.24
	2		-19.96	12.57		-1.59
	3&4		-97.12	17.65		-5.50
1991			-241.83	66.22		-3.65
1992			114.91	68.03		1.69
1993			-757.32	58.62		-12.92
1994			-280.52	38.55		-7.28
1995			-561.58	48.13		-11.67
1996			46.41	90.03		0.52
1997			-341.02	48.64		-7.01
1998			183.55	44.07		4.16
1999			166.74	49.31		3.38
2000			104.07	49.68		2.09
2001			-109.31	72.31		-1.51
2002			-272.95	53.65		-5.09
2003			83.81	42.08		1.99
2004			222.57	47.33		4.70
2005			-734.96	40.90		-17.97
2006			-226.00	56.11		-4.03
2007			-347.38	39.30		-8.84
2008			623.07	51.38		12.13
2009			647.63	34.68		18.67
2010			596.48	37.76		15.80
2011			-177.82	38.60		-4.61
2012			-207.70	38.46		-5.40
2013			102.45	34.21		2.99
2014			532.30	41.55		12.81

Precision Farming Conclusions

- Both spatial (zone) and temporal (time) variability had significant effects on crop productivity, but temporal variability had the greater effect.
- Excessive moisture (2005&2011) or drought (2006) caused more than 24% wheat yield loss or about $100/ha net loss.
- Excessive moisture (2005&2011) or drought (2006) caused on average 25% canola yield loss or more than $170/ha net loss.
- Importance of tile drainage in Manitoba