Economics of Alternative Input Use and Crop Diversity Strategies in the Dark Brown Soil Zone of Saskatchewan

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Introduction

Declining commodity prices coupled with rapidly rising input costs are causing many producers in western Canada to question the merits of conventional high-input agricultural production systems. In response, producers have become increasingly interested in extending and diversifying their cropping systems, and in adopting low-input and organic management practices.

The objective of this study was to compare production costs, economic returns, and riskiness of nine cropping systems, representing three levels of input usage (high, reduced, and organic), and three levels of cropping diversity (low crop diversity, diversified with annual grains, and diversified with annual grains and forages). The paper draws on data from the first 6 years of a long-term field experiment being conducted in the Dark Brown soil zone at the Scott Experimental Farm.

Economic Analysis - Materials Methods

The economic analysis follows methods used previously by Zentner et al. (1992) and Zentner and Campbell (1988). Spreadsheet programs were developed to determine and compare annual total and unit costs of production, amount and seasonal distribution of resource needs (e.g., fertilizer, herbicide, fuel, machine repair, labor, specialized equipment needs), level of gross and net returns (i.e., income remaining after paying for all cash costs, plus labor and overhead costs for machines and buildings), and riskiness (income variability) for each cropping system. A total of nine cropping systems (all 6 years in length), representing three levels of input usage (i.e., “high” which uses recommended rates of fertilizers and pesticides as required; “reduced” which uses reduced inputs of fertilizer, pesticides, and fuel; and “organic” which uses non-chemical pest control methods and legume green manure) and three levels of cropping diversity (i.e., low diversity (LOW), diversified using annual grains (DAG), diversified using annual grains and perennial forages (DAP)), were evaluated using data from the 1996 to 2000 period (Table 1). Data from the initial year of the experiment (i.e., 1995) were excluded from the analysis because all crops were not yet in proper sequence and thus would not reflect true treatment effects.

The experimental data were extrapolated to the farm-level using a representative farm of 777 ha and a typical complement of machinery for each cropping system. Costs for inputs were held constant at their 2000 levels (Table 2 and Table 3) (Saskatchewan Agriculture and Food, 2000). Products were valued at their respective 1996/97 - 1998/99 average farm-gate prices (net of elevation, transportation, and storage costs) (Table 4). Wheat prices were adjusted for protein concentrations obtained in the respective treatments using the 1996/97 - 1998/99 average protein price premium schedule as established by the Canadian Wheat Board. The analysis was repeated for three organic grain price scenarios: (i) price premiums received on 50% of the organically grown grains produced (reflects a situation where one-half of the organic production is sold in the organic market and the other half is sold in the conventional or commercial market), (ii) no price premiums over conventionally grown grains (reflects a situation faced by organic producers during the certification period), and (iii) price premiums received on 100% of the organically grown grains produced (reflects a situation where all organic production is sold in the organic market). Participation in the Canada/Saskatchewan all-risk crop insurance program was assumed for all treatments using the 70% yield coverage option for all cereal, oilseed, and pulse crops. Forage was assumed to be uninsured. Premium rates and payout criteria for the respective conventionally and organically grown crops in Risk Area #20 were assumed (Saskatchewan Crop Insurance Corporation, 2000a,b).

Table 1. Summary of cropping systems

Crop diversity	**Input level**	**Crop sequence**[1]
LOW (low diversity of	High	F_T-W-W-F_T-C-W
annual grains)	Reduced	L_{GM}-W-W-F_C-C-W
	Organic	L_{GM}-W-W-L_{GM}-C-W
DAG (diversified using	High	C-R-P-B_M-F_X-W
annual grains)	Reduced	C-R-P-B_M-F_X-W
	Organic	L_{GM}-W-P-B_M/S_C-S_{CGM}-C
DAP (diversified using	High	C-W-B_F-O/B_R&A-H-H
annual grains and	Reduced	C-W-B_F-O/B_R&A-H-H
perennial forages)	Organic	C-W-B_F-O/B_R&A-H-H

[1] F_T = tillage fallow, W = wheat, C = canola, L_{GM} = lentil green manure, F_C = chemical fallow, P = field pea, B_M = malt barley, B_F = feed barley, S_C = sweet clover, S_{CGM} = sweet clover green manure, R = fall rye, F_X = flax, O = oats, B_R&A = bromegrass-alfalfa, and H = hay.

All findings were expressed on per hectare basis for the complete cropping systems, which includes the costs and returns for all phases or components of each treatment.

Table 2. Selected farm input costs

Pesticides	**Cost ($)**	**Unit**
2,4-D	4.55	litre
Achieve DG	162.00	kg
Assure II	82.50	litre
Avadex BW	2.53	kg
Banvel	32.90	litre
Buctril M	15.94	litre
Dyvel DS	12.70	litre
Edge	1.96	kg
Lontrel	137.05	litre
Mataven	7.00	litre
MCPA Amine	6.25	litre
Muster	1.87	gram
Sodium Salt	4.50	litre
Poast	38.19	litre
Reglone	22.00	litre
Roundup	8.99	litre
Rustler	5.99	litre
Sencor	63.70	litre
Tropotox Plus	11.83	litre
Lorsban 4E	15.62	litre
Tilt	67.80	litre
Decis	129.30	litre
Seed costs		
Alfalfa	5.52	kg
Bromegrass	3.50	kg
Sweet clover	2.95	kg
Indianhead black lentil	0.55	kg
Seed treatments		
Premiere Plus	50.71	litre
JumpStart	2.09	gram
Vitavax RS Flowable	65.63	litre
Vitavax Dual	36.66	litre
Vitavax Powder	34.66	litre
Seed inoculants		
Pea	0.05	kg seed
Lentil	0.08	kg seed
Alfalfa	0.22	kg seed
Sweet clover	0.22	kg seed
Fertilizers		
12-51-0	0.36	kg
46-0-0	0.35	kg
34-0-0	0.33	kg
Fuel		
Gas	0.55	litre
Diesel	0.52	litre

Table 3. Selected field operations and other related costs

Field operation	Cost ($ ha^{-1})
Combine	34.02*
Haul grain	11.59*
Round bale	22.36*
Haul bales	10.11*
Broadcast	5.32
Double disk press drill	17.84
Field cultivator	8.19
Harrow	5.40
Harrow packer	7.66
Harrow packer & harrow	9.72
Haybine	27.92
Heavy duty cultivator	9.52
Heavy duty cultivator & harrow packer	15.68
Heavy duty cultivator with tine harrows	10.64
Heavy duty cultivator with tine harrow & harrow packer	16.80
Heavy duty cultivator with trailing rodweeder	10.92
Heavy harrow	3.34
Hoe drill	19.22
Land roller	5.43
Manure application	20.97
Medium duty cultivator	8.19
Medium duty cultivator with tine harrows	9.31
Medium duty cultivator with trailed rod & harrows	11.81
Cultivator with spikes	9.52
Rodweeder	7.48
Swath	9.21
Sprayer	6.40
Haul water	0.91
Other related costs	
Interest rate	8.00 (%)
Miscellaneous	11.68
Land taxes	10.85
Labor	9.00 ($ hr^{-1})

*Based on 2000 kg ha^{-1} yield.

Table 4. 1996/97 - 1998/99 average net farm prices ($ t^{-1}) for conventional and organically grown crops

Crop (% Protein)	Conventional	Organic
Wheat (<11.99%) - base	146.17	261.67
Wheat (12.0 to 12.499%)	149.87	265.37
Wheat (12.5 to 12.999%)	153.47	268.97
Wheat (13.0 to 13.499%)	157.17	272.67
Wheat (13.5 to 13.999%)	162.17	277.67
Wheat (14.0 to 14.499%)	167.17	282.67
Wheat (14.5 to 14.999%)	173.17	288.67
Wheat (15.0% or more)	179.17	294.67
Barley – feed	99.09	145.40
Barley – malt	147.06	246.00
Rye	93.15	193.00
Oats	96.82	217.00
Canola	361.19	640.00
Flax	314.45	697.00
Pea	184.67	350.67
Hay (dry matter basis)	82.65	82.65

Source: M. Gimby, Saskatchewan Research Council

Results and Discussion

Overall Annual Economic Performance

The annual economic performance of the cropping systems varied greatly among years (Table 5), largely reflecting the effects of growing season weather conditions on crop yields and grain quality. Gross and net returns (when averaged over cropping treatments) were highest in 1999 and intermediate in 1996 and 2000 when precipitation was above normal, and lowest in the drier years of 1997 and 1998. In contrast, average total costs were relatively similar among study years.

Table 5. Mean annual economic performance of cropping systems (price premiums received on 50% of organically grown grains) ($ ha^{-1})

Economic parameter	1996	1997	1998	1999	2000
Gross returns	332	252	208	412	327
Total costs	189	177	176	182	218
Net returns	143	75	32	230	109

Economic Performance by Crop Diversity and Input Level

i) Price Premiums for 50% of Organically Grown Grains

Gross returns for the nine cropping systems averaged \$230 ha^{-1} during the dry years and \$357 (or 55% more) during the wet years (Table 6). In dry years, gross returns (averaged over Input Levels) were highest and about similar for the DAG and LOW Crop Diversity treatments (\$249 ha^{-1}), and lowest for DAP (23% less). Alternatively, when averaged over Crop Diversity levels, gross returns were highest for the Reduced Input treatments (\$248 ha^{-1}), intermediate for High Input (7% less), and lowest for Organic Input treatments (15% less). Overall, the cropping systems that provided the highest gross returns during dry years were DAG with High Input and DAG with Reduced Input (\$283 ha^{-1}), and the cropping system that provided the lowest gross return was DAP with Organic Input (36% less). In contrast, during wet years, gross returns (averaged over Input Levels) were highest for DAG (\$427 ha^{-1}), intermediate for LOW (13% less), and lowest for DAP (36% less); when averaged over Crop Diversity levels, they were highest for High Input (\$398 ha^{-1}), intermediate for Reduced Input (11% less), and lowest for Organic Input (20% less). Thus the cropping system with the highest gross returns during wet years was DAG with High Input, and the system with the lowest gross return was DAP with Organic Input, in part reflecting the lack of organic price premiums for forage hay. When averaged over the 5 study years (1996–2000), the ranking of gross return were for the treatments were similar as for the wet years.

Total production costs over the dry years averaged between \$137 and \$219 ha^{-1}, and were lowest for the DAP and for the Organic Input treatments, and highest for DAG and the High Input treatments (Table 6). The DAG treatments required the highest expenditure for purchased inputs (\$214 ha^{-1}) (Table 7). Expenditures for DAP treatments averaged 21% lower (\$44 ha^{-1} less) and LOW treatments averaged 16% lower (or \$34 ha^{-1} less) than for DAG. The resource categories most affected by changes in Crop Diversity levels were seed, fertilizer, chemicals, and machinery overhead. Seed costs (including seed treatments) accounted for about 14%, fertilizers 10%, chemicals 12%, and machinery overhead for 26% of the respective total costs for each Crop Diversity treatment.

Total production costs also varied considerably among the Input Level treatments (Table 8). Total expenditures for Organic Input treatments averaged 21% less (or \$44 ha^{-1} lower) than for High Input and Reduced Input treatments. The largest differences in expenditures were for fertilizer and chemical inputs which were not used by Organic Input treatments, and for (most) seed costs which were higher for Organic Input treatments because of their higher market value. Expenditures for machinery operation and ownership were generally similar for the High Input and Organic Input treatments, and lowest for the Reduced Input treatments (about 20% less).

Table 6. Effect of crop diversity and input level in dry years (1997 and 1998), wet years (1996, 1999 and 2000), and overall on costs and returns for cropping systems - Price premiums received on 50% of organically grown grains ($ ha^{-1})

Dry Years		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	219	283	189	231
	Total Cost	175	219	176	190
	Net Return	44	64	14	41
Reduced	Gross Return	260	282	202	248
	Total Cost	174	203	163	180
	Net Return	86	79	39	68
Organic	Gross Return	260	191	181	211
	Total Cost	169	172	137	159
	Net Return	91	19	44	52
Mean Gross Return		246	252	191	230
Mean Total Cost		173	198	159	177
Mean Net Return		74	54	32	53

Wet Years		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	409	476	308	398
	Total Cost	196	259	192	216
	Net Return	213	217	116	182
Reduced	Gross Return	348	443	270	354
	Total Cost	196	248	196	213
	Net Return	153	195	74	142
Organic	Gross Return	355	363	239	319
	Total Cost	163	167	147	159
	Net Return	192	195	93	160
Mean Gross Return		371	427	272	357
Mean Total Cost		185	225	178	196
Mean Net Return		186	204	94	161

5-Year Mean		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	333	399	260	331
	Total Cost	187	243	186	205
	Net Return	145	156	75	125
Reduced	Gross Return	313	379	243	312
	Total Cost	187	230	183	200
	Net Return	126	149	60	112
Organic	Gross Return	317	294	216	276
	Total Cost	165	169	143	159
	Net Return	152	125	73	117
Mean Gross Return		321	357	240	306
Mean Total Cost		180	214	170	188
Mean Net Return		141	144	69	118

Table 7. Effect of crop diversity on 5-year (1996-2000) average production costs - Price premiums received on 50% of organically grown grains (\$ ha^{-1})

5-Year Mean	Crop Diversity			
Resource	LOW	DAG	DAP	Mean
Oil, lube and fuel	16	17	15	16
Labor	7	8	7	7
Machinery repairs	15	17	14	15
Machinery overhead	48	54	42	48
Chemicals	21	30	16	22
Fertilizers	17	24	19	20
Seed	23	30	25	26
Crop ins. premium	5	5	3	4
Miscellaneous	12	12	12	12
Taxes	11	11	11	11
Interest	5	6	5	5
Total cost	180	214	170	188

Table 8. Effect of crop diversity on 5-year (1996-2000) average production costs - Price premiums received on 50% of organically grown grains (\$ ha^{-1})

5-Year Mean	Input Level			
Resource	High	Reduced	Organic	Mean
Oil, lube and fuel	18	11	19	16
Labor	8	6	8	7
Machinery repairs	17	14	15	15
Machinery overhead	50	43	51	48
Chemicals	32	35	0	22
Fertilizers	29	31	0	20
Seed	18	26	34	26
Crop ins. premium	4	4	4	4
Miscellaneous	12	12	12	12
Taxes	11	11	11	11
Interest	6	6	4	5
Total cost	205	200	159	188

The cropping system which earned the highest average net return during dry years was LOW with Organic Input (\$91 ha^{-1}), followed closely by LOW with Reduced Input (5% less) and DAG with Reduced Input (13% less) (Table 6). The cropping system with the lowest net returns during dry years was DAP with High Input management. In contrast, the most profitable cropping systems during wet years was DAG with High Input management (\$217 ha^{-1}), followed by LOW with High Input and DAG with Reduced or Organic Input management (10% less); the poorest performing system was DAP with Reduced Input.

Based on the 5-years of results and the assumption that 50% of the organically grown grains received price premiums, the most profitable cropping systems were LOW with Organic Input, and DAG with High Input or with Reduced Input (Table 6).

ii) No Price Premiums for Organically Grown Grains

Under the assumption of no price premiums, which would be typical of new organic producers who have not yet completed the certification period, the relative profitability of the Organic Input treatments were substantially reduced (Table 9). Net returns for the organically managed LOW, DAG, and DAP treatments declined by an average of \$61, \$43, and \$35 ha^{-1}, respectively, in dry years, and by \$112, \$100, and \$54 ha^{-1} in wet years (compared to the 50% price premium scenario). The most profitable cropping systems were LOW and DAG with Reduced Input management in dry years, and in wet years it was these same two Crop Diversity systems but with High Input management.

Based on the 5-year average performance under the assumption of no price premiums for organically grown grains, the most profitable cropping systems were DAG with High Input and Reduced Input management, with the LOW system using High Input management ranking second highest (Table 9).

iii) Price Premiums For 100% of Organically Grown Grains

Under the assumption that all grains grown using organic management methods received the full price premiums, the relative profitability of the Organic Input treatments were increased substantially (Table 10). Net returns for organically managed LOW, DAG, and DAP treatments increased (relative to the 50% price premium scenario) by a further \$28 to \$44 ha^{-1} in dry years and by \$44 to \$88 ha^{-1} in wet years, with the increases being smallest for the DAP treatments. The most profitable cropping system was LOW with Organic Input management in dry years, and DAG with Organic Input management in wet years. Overall, the most profitable cropping system under this price scenario was LOW with Organic Input management, followed by DAG with Organic Input management (12% less).

Riskiness

When choosing among cropping systems, producers are often faced with a trade-off between increases in annual net returns and increases in income variability or financial risk. As producers become increasingly risk averse, they tend to choose cropping systems that display lower income variability. The final choice or selection of a cropping system depends upon the risk attitudes of individual producers (their willingness to gamble), expectations on product prices and input costs, and the nature of the distributions of probable net returns that can be earned with each cropping system. Under the conditions of this study, net income variability (or risk) tended to be lowest for DAG, intermediate for LOW, and highest for the DAP cropping systems (Table 11). With one exception, income variability tended to be lowest with Organic Input < Reduced Input < High Input. Overall, the cropping system that displayed the lowest income variability was DAG with Reduced Input management.

Table 9. Effect of crop diversity and input level in dry years (1997 and 1998), wet years (1996, 1999 and 2000), and overall on costs and returns for cropping systems - No price premiums for organically grown grains ($ ha^{-1})

Dry Years		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	219	283	189	231
	Total Cost	175	219	176	190
	Net Return	44	64	14	41
Reduced	Gross Return	260	282	202	248
	Total Cost	174	203	163	180
	Net Return	86	79	39	68
Organic	Gross Return	192	141	143	159
	Total Cost	162	166	134	154
	Net Return	30	-24	9	5
Mean Gross Return		224	236	178	213
Mean Total Cost		170	196	158	175
Mean Net Return		53	40	20	38

Wet Years		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	409	476	308	398
	Total Cost	196	259	192	216
	Net Return	213	217	116	182
Reduced	Gross Return	348	443	270	354
	Total Cost	196	248	196	213
	Net Return	153	195	74	142
Organic	Gross Return	236	255	183	225
	Total Cost	156	160	144	153
	Net Return	80	95	39	71
Mean Gross Return		331	392	254	325
Mean Total Cost		183	222	177	194
Mean Net Return		148	170	77	131

5-Year Mean		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	333	399	260	331
	Total Cost	187	243	186	205
	Net Return	145	156	75	125
Reduced	Gross Return	313	379	243	312
	Total Cost	187	230	183	200
	Net Return	126	149	60	112
Organic	Gross Return	219	210	167	198
	Total Cost	159	162	140	154
	Net Return	60	48	27	44
Mean Gross Return		288	329	223	280
Mean Total Cost		178	212	169	186
Mean Net Return		110	117	54	94

Table 10. Effect of crop diversity and input level in dry years (1997 and 1998), wet years (1996, 1999 and 2000), and overall on costs and returns for cropping systems - Price premiums received on 100% of organically grown grains ($ ha^{-1})

Dry Years		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	219	283	189	231
	Total Cost	175	219	176	190
	Net Return	44	64	14	41
Reduced	Gross Return	260	282	202	248
	Total Cost	174	203	163	180
	Net Return	86	79	39	68
Organic	Gross Return	308	234	211	251
	Total Cost	173	178	139	163
	Net Return	135	55	72	88
Mean Gross Return		262	266	201	243
Mean Total Cost		174	200	159	178
Mean Net Return		88	66	42	65

Wet Years		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	409	476	308	398
	Total Cost	196	259	192	216
	Net Return	213	217	116	182
Reduced	Gross Return	348	443	270	354
	Total Cost	196	248	196	213
	Net Return	153	195	74	142
Organic	Gross Return	439	457	286	394
	Total Cost	167	174	149	163
	Net Return	272	283	137	231
Mean Gross Return		399	459	288	382
Mean Total Cost		186	227	179	197
Mean Net Return		213	232	109	185

5-Year Mean		Crop Diversity			
Input Level	Parameter	LOW	DAG	DAP	Mean
High	Gross Return	333	399	260	331
	Total Cost	187	243	186	205
	Net Return	145	156	75	125
Reduced	Gross Return	313	379	243	312
	Total Cost	187	230	183	200
	Net Return	126	149	60	112
Organic	Gross Return	387	368	256	337
	Total Cost	169	176	145	163
	Net Return	218	192	111	174
Mean Gross Return		344	382	253	326
Mean Total Cost		181	216	171	190
Mean Net Return		163	166	82	136

Table 11. Index of annual variability in net returns for cropping systems – Price premiums received on 50% of organically grown grains

Input/Crop Diversity	LOW	DAG	DAP
High	164	113	217
Reduced	155	98	208
Organic	134	195	194

Conclusions

As expected with the limited dataset, the economic performance of the nine production systems varied among years, and depended greatly on the eligible quantities of product sold into the organic market (or the price premiums received for organically grown grains). Based on the five years of results reported, the findings suggest that the Crop Diversity treatment, DAG, is most profitable under wet conditions despite its higher costs of production, and LOW is best under dry conditions. The DAP system was not economically competitive under the price assumptions used in this analysis, in part due to the lack of a direct price premium for organically grown forage hay. With respect to the Input Level treatments, the use of High Input management was more profitable in wet years when the response to management inputs (e.g., fertilizers and pesticides) is greatest due to the favorable growing conditions. The Reduced Input management treatments, with its lower cash outlay requirements, performed well in dry years, and may represent a good risk management strategy for drought situations. The use of Organic Input management was more profitable than the High Input or Reduced Input management systems under the 1996/97 - 1998/99 price premiums levels that existed for organic grains. These findings bode well for organic producers who are fully certified and are able to sell most or all of their production into organic markets and can capture the full price premiums. However, the findings also suggest that for new organic producers farm incomes may be lower during the three-year certification period.

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