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Economics of Mixed Farming under Rotational Grazing with Low Input System

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Abstract

This study was conducted at the Manitoba Zero Tillage Research Farm (MZTRA) located 17.6 kilometres north of Brandon, Manitoba. The objective was to evaluate new farming systems designed to improve economic return, sequester carbon, and reduce inputs, energy use, and greenhouse gas emissions of mixed production systems. Yield and net revenue varied across MZTRA landscapes due to spatial and temporal variability of soil fertility and biophysical properties. Relative to studies with conservation tillage in the Canadian Prairies, producers can expect to achieve higher crop yields with most crops under zero tillage. Compared to crop yields reported for conventional tillage (CT) in Thin Black soil zone of Saskatchewan, spring wheat was 11 to 32% higher, winter wheat 41 to 66% higher, pea 27% higher, and flax was comparable. There were no significant differences in total input cost among annual crop rotation. Our results indicated that small-scale mixed crop and livestock operations had higher operating costs, the success of which depended on animal and environmental conditions as well as management. Hay and grazing systems also had higher risk. Among annual crops, although net revenue was higher for canola and peas, risk was also higher due to higher net revenue variation for these two crops. The findings showed that the use of zero tillage with low inputs has the potential to save energy use and improve energy use efficiency. The use of zero tillage provided significant energy savings (compared to CT reported by Zentner et al. (2004)) in on-farm use of fuel and in machine operation and manufacture. The ratio of grain, oilseed and pea yield to emission of CO_2 (kg yield per kg CO_2 emitted) varied considerably between crops. This ratio was similar for winter wheat and spring wheat, but not for canola and flax. Canola ratios were higher than flax (2.03 compare to 1.92 kg of flax). Peas had a higher ratio (8.47 kg), due to low fertilizer rates. Alfalfa had the highest ratio (17.8 kg yield kg CO_2, due to low inputs of fertilizer and pesticides. Overall the crops and rotations studied were highly energy efficient and reduced the calculated contribution of GHGs to the environment especially when legume and N-fixing crops were incorporated.

Introduction

Declining farm income and increased awareness about environmental issues are encouraging many producers in western Canada to consider alternative tillage practices and low fertilizer input managements that are designed to conserve soil and resource inputs. There is also some evidence supporting a mixed operation of crop and livestock to improve profitability of farm enterprises. It is argued that, for example, rotational grazing systems have the potential to reduce input costs, reduce animal maintenance costs, and improve stocking rates. However, limited information is available about the merits of these management changes on the overall input requirements, profitability and use efficiency of non-renewable energy forms. Assessing the economic and energy conservation of a mixed farming system with low-input management practices will provide useful information for producers who adopt such practices.

Objective
The main objective of this study was to evaluate economic return, energy use efficiency, and carbon sequestration and greenhouse gas emissions of a mixed cropping and livestock farming system with conservation practices and using low inputs of machinery and fertilize and chemical application.

Materials and Methods
This study is one of the field scale studies started at the Manitoba Zero Tillage Research Farm (MZTRA) in 2001. The farm is located 17.6 kilometres north of Brandon, Manitoba. In the first year all fields were seeded to canola. Low input rotations were established in May 2002. Only data up to 2004 were used in our analysis and rotations so far include: a) winter wheat-peas-canola (WW-P-C), b) spring wheat-flax-canola (SW-F-C), and c) canola-alfalfa/orchard-alfalfa/orchard-alfalfa/orchard (C-A-A-A). The cropping system was replicated in two fields. The forage based system was replicated in two fields where fields were divided into hay and grazing systems and the objective was to evaluate grazing alfalfa in a forage based rotation. In 2003, 32 cattle (757 lb avg.) were grazed for about 100 days in two separate replicates, Field 104 and 204, with average daily gain of 1.75 lb. Each pasture was divided into 3 paddocks. Because the total area of Field 204 was greater than 104, and the alfalfa had better establishment in 204, a higher stocking rate was chosen for this field. The stocking rate in 104 was 1.35 acres/head; in Field 204 it was 1.22 acres/head. The rotation resulted in a 2-times-over grazing system for both fields. In 2004, the farm grazed 39.2 acres of alfalfa with 40 yearling steers (659 lb avg.) with average daily gain of 2.49 lb. The cattle grazed on 2 replicated pastures, each consisting of 6 paddocks, with a stocking rate of 1.02 acres per head. The cattle were moved every 4-5 days on average, in a 4-times-over grazing system. The rest period of the paddocks was 20-25 days. Data from the initial year were excluded from our analysis as crops were not yet properly established and thus did not reflect the true treatment effects.

Results and Discussion
Net Income and Costs
The economic performance of each system was evaluated based on estimated net income (Tables 1-3). Net income was calculated as the income remaining above cash costs (for example, seed, fertilizer, chemical, fuel and oil, and repairs), ownership costs (for example, depreciation and interest on investment), and labour. All annual inputs used in each phase of rotation for each management treatment (for example, pre-plant activities, fertilization, planting, insects and pests control, harvesting, storage, and transportation) were included in the analysis.

There were differences in input costs and yield for each crop and within each rotation. This caused variation in net revenue among crops and rotations. For example, net revenue for WW-P-C is $114/ha for Field 101 compare to $72/ha for Field 201. This variation can be explained by higher yield of peas and canola in Field 101 (data not presented here). The results also reveal that mixed hay and grazing systems produced significantly lower net revenue compare to hay-only production. Small-scale grazing operation and, therefore, higher operating costs, dryer and lower yield in 2003, higher average weight-in of steers and lower daily weight gain in 2003, and unfamiliarity with grazing management in the first year of establishment altogether have caused net revenue of hay and grazing system become significantly lower as compared to 2004 and hay-only operation (Table 3). Machinery/fuel/repair (MFR) (31%), chemical (22%), fertilizer (18%), seed (15%), and other costs (13%) were the major costs for WW-P-C rotation. These values were 26%, 34%, 17%, 10%, and 13% for SW-F-C, respectively. Fertilizer cost was zero for hay system and chemical cost was very minimal. However, MFR (42%), labour (19%), and other costs (29%) were the major input costs for hay and grazing system. These values were 59%, 12%, and 11% for the hay-only system, respectively.

Table 1. Net Revenue of Rotations at the MZTRA Research Farm, 2002-2004

Rotations	Net Revenue ($/ha)	Net Revenue Less Labor ($/ha)	Coefficient of Variation
Field 101 WW-P-C	114		
Field 102 SW-F-C	112		
Field 103 SW-F-C	103		
Field 201 WW-P-C	72		
Field 202 SW-F-C	111		
Field 203 SW-F-C	118		
WW-P-C	93		55
SW-F-C	111		33
SW-F-C	111		40
Hay and Grazing[1]	65	156	177
Just Hay[1]	104	133	41

[1]Only net revenue of 2003-2004 is reported here.

Table 2. Crops, Alfalfa Hay and Grazing Net Revenue ($/ha)

Crops	Average	Std. Dev.	CV
Winter Wheat	111.0	4.6	4.1
Spring Wheat	85.1	4.6	5.4
Peas	127.6	44.7	35.1
Flax	86.7	22.1	25.4
Canola	120.8	66.1	54.7
Hay and Grazing[1]	65.2	115.7	177.4
Just Hay[1]	104.0	42.6	41.0
Hay and Grazing Less Labor[1]	156.4	106.9	68.4

[1]Only net revenue of 2003-2004 is reported here.

Table 3. Net Revenue of Grazing and Hay System ($/ha), 2003-2004.

	Combined Hay and Grazing ($/ha)			Just Hay ($/ha)		
	Fields			Fields		
Year	104	204	Average	104	204	Average
2003	7.2	-58.8	-26	112.5	51.3	82
2004	107.0	205.5	156	97.6	154.6	126
Average	57	73	65	105	103	104

Energy Use and Greenhouse Gas Emission

All direct and indirect non-renewable energy going into manufacturing, formulation, packaging, transportation, maintenance and application of all purchased inputs used in each production system were included. Gross energy output was defined as (yield – seed) * grain energy + animal retained energy (if applicable). Energy use efficiency was calculated as: i) net energy produced (energy output, E_o, minus energy input, E_i), ii) ratio of E_o to E_i, and iii) quantity of grain or hay produced per unit of E_i.

Tables 4-5 show energy indicators for the rotations and each individual crop. Gross energy output from the harvested grain (crop residues were returned to the land) for the complete annual crop rotations averaged 46473 MJ ha^{-1} for the SW-F-C rotation, and 52884 MJ ha^{-1} (or 14% more) for WW-P-C rotation. Energy output of the alfalfa rotation averaged 86314 MJ ha^{-1}. Compared to other studies for the Black soil zone, gross energy output increased under zero tillage relative to conventional tillage, due to increased crop yields. Grain produced per unit of input energy was higher for peas (1189 kg/GJ) than any other crop, reflecting the lower E_i required. Grain produced per unit of energy ranked P > WW > SW > C > F > hay-only. Overall, WW-P-C rotation had greater energy efficiency than SW-F-C rotation; peas and hay were highly energy efficient with no or minimal fertilizer use. Pea has also lower or comparable net energy with winter wheat and spring wheat because of lower pea yield especially in Field 201. Fertilizer (67%; primarily N) and fuel (20%) were the major renewable energy inputs for averaged crop rotations with chemicals representing about 9% of the total E_i. For the hay system, chemicals and fuel were the main energy costs since no fertilizer was used.

The ratio of grain, oilseed and pea yield to emission of CO_2 (kg yield per kg CO_2 emitted) varied considerably between crops (Figure 1). This ratio was similar for winter wheat and spring wheat, but not for canola and flax. Canola ratios were higher than flax (2.03 compare to 1.92 kg of flax). Peas had a higher ratio (8.47 kg), due to low fertilizer rates. Alfalfa had the highest ratio (17.8 kg yield kg CO_2, due to low inputs of fertilizer and pesticides.

Table 4. Energy Efficiency Indicators for each Rotation

Rotations	Net Energy (MJ/ha)	Ratio = E_o/E_i [1]
Field 101 WW-P-C	48460	8.245
Field 102 SW-F-C	37958	6.628
Field 103 SW-F-C	40272	6.826
Field 201 WW-P-C	44035	7.689
Field 202 SW-F-C	37988	6.399
Field 203 SW-F-C	41780	6.804
WW-P-C	46248	7.969
SW-F-C	37973	6.511
SW-F-C	41026	6.815
Hay and Grazing	88012	34.486
Just Hay	84740	54.841

1 E_o is total energy output; E_i is total energy input

Table 5. Non-renewable energy input, output and use efficiency of crops and alfalfa

	Winter Wheat	Spring Wheat	Peas	Flax	Canola	Hay and Grazing	Hay
				(MJ ha^{-1})			
Fertilizer	7331	4620	133	4840	5092	0	0
Herbicides	821	860	435	810	315	849	849
Fuel & lubricants	1640	1391	1573	1100	1338	416	416
Machinery overhead	301	261	292	215	264	1005	310
Total energy input	10094	7133	2432	6965	7008	2628	1574
Gross energy output	69833	47814	50142	37424	49012	90640	86314
Net energy produced	59740	40681	47710	30459	42004	88012	84740
Grain/energy input[X] (KGs/GJ)	383	377	1189	212	238		2921
Grain/energy input for CT reported by Zentner et al., 2004 (KGs/GJ)	302	284	485	240			
Output/Input ratio	6.92	6.72	20.65	5.38	7.03	34.49	54.84

[X] Units are kg of grain produced per GJ of energy input.

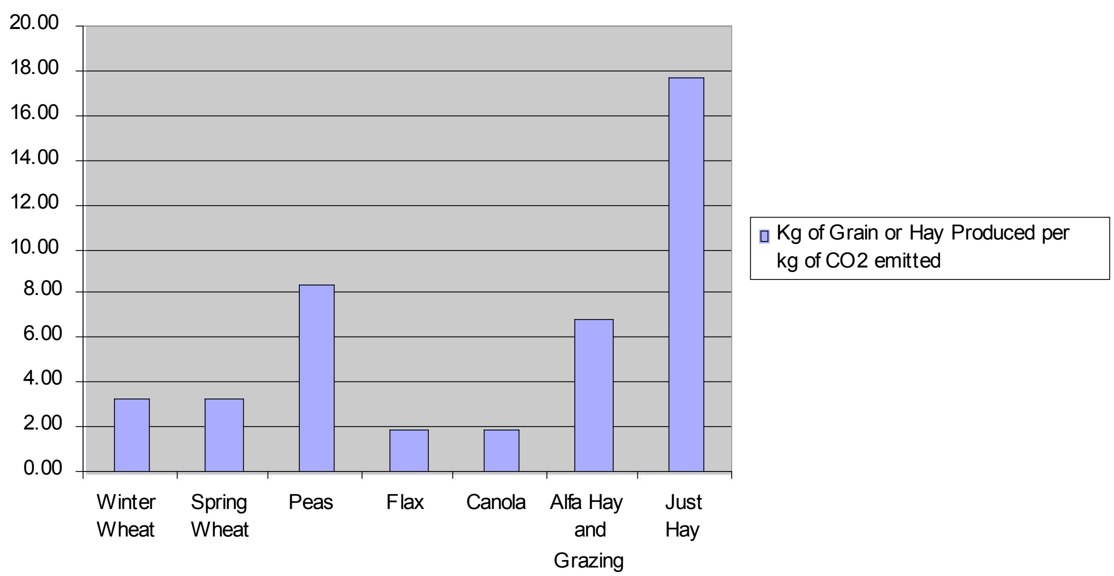

Figure 1. Quantity of grain and hay produced per kg of CO_2 emitted

Conclusion

This study was designed to evaluate new farming systems to improve economic return, sequester carbon and reduce inputs, energy use, and greenhouse gas emissions of mixed production systems. Yield and therefore net revenue varied across the MZTRA site, and was attributed to soil fertility and biophysical characteristics. The results indicate that higher operating costs are involved with small scale mix crop and livestock operation and its success heavily depends on animal and environmental conditions as well as management. Coefficient of variation of net revenue for hay and gazing system was significantly higher indicating higher risk involved with this system. Although the net revenue was higher for canola and peas their CVs were also higher compare to other crops indicating higher net revenue variation for these two crops. Overall cropping and farming managements in MZTRA are proven to be highly energy efficient and reduce the contribution of GHGs to the environment especially when legume and N-fixing crops are incorporated into the rotations.

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References

Janzen, H. H.; Angers, D. A.; Boehm, M.; Bolinder, M.; Desjardins, R. L.; Dyer, J. A.; Ellert, B. H.; Gibb, D. J.; Gregorich, E. G.; Helgason, B. L.; Lemke, R.; Masse, D.; McGinn, S. M.; McAllister, T. A.; Newlands, N.; Pattey, E.; Rochette, P.; Smith, W.; VandenBygaart, A. J., and Wang, H. 2006 A proposed approach to estimate and reduce net greenhouse gas emissions from whole farms. Canadian Journal of Soil Science. May; 86 (3):401-418

Gill, R.S., Nagy, C.N., Zentner, R.P., Hucq, A., MacGregor, R.J., Entz, M.H., Giraldez, J.C., 2001. Opportunities for reduced non-renewable energy use in Canadian Prairie agricultural production systems. Publ. 2082/B. Agriculture and Agri-Food Canada. Policy Branch. Ottawa, ON. August. 49 pp.

Nagy, C.N., Johnston, A.M., Wall, D.D., Zentner, R.P., Gill, R., 2000. Influence of tillage method on nonrenewable energy use efficiency in the Black and Gray soil zones. *In* Proc. Climate Change Workshop, Saskatoon, SK, December. [CD-ROM] Available: Saskatchewan Agriculture and Food, Regina, SK.

Zentner R. P., G. P. Lafond, D. A. Derksen, and C. A. Campbell. 2002b. Tillage method and crop diversification: effect on economic returns and riskiness of cropping systems in a Thin Black Chernozem of the Canadian Prairies. Soil and Tillage Research. Volume 67, Issue 1, Page 9-21.

Zentner R. P., G. P. Lafond, D. A. Derksen, C.N. Nagy, and D.D. Wall. 2004. Effects of tillage and crop rotations on non-renewable energy use efficiency in the Thin Black soil zone of the Canadian Prairies. Soil and Tillage Research. Volume 77, Issue 2, Pages 125-136.