LIFE CYCLE ASSESSMENT OF ALFALFA-GRASS HAY PRODUCTION IN MANITOBA

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INTRODUCTION & ASSUMPTIONS

Background

❑Tame hay estimated to cover over 750,000 ha in 2013, exceeded only by canola and wheat.

❑ Alfalfa-grass mixtures are the most common types of tame hay.

❑Objective: To determine energy use and greenhouse gas (GHG) emissions per tonne of hay in order to recommend areas of improvement.

❑Methodology: ISO compliant cradle-to-farm gate Life Cycle Assessment (LCA),SimaPro 8.2, life cycle software. Holos 2.1.1.

Assumptions

❑Seeded to alfalfa, smooth brome, and timothy, 9.0, 2.2, and 2.2 kg/ha, respectively.

❑Hay receives manure from adjacent overwintering dry lot.

❑Hay is cut with a rotary disc mower-conditioner and baled to produce 654 kg round bales using poly twine.

❑Bales are loaded with tractor and hay fork; hauled 3.2 km (field to farm); 17 bales per load.

Table 1. Assumed yield, inputs, fuel consumption and carbon (C) sequestration for MB hay production.

Assumption	Year 1	Year 2	Year 3	year 4	Year 5	Year 6	TOTAL over 6 yrs	Units
Yield for the year	2.69	6.05	6.95	6.95	6.50	4.04	**33.18**	t/ha
Seeding rate	13.45						**13.45**	kg/ha
Potash fertilizer (MOP)	158.79			158.79			**317.58**	kg/ha
Phosphate fertilizer (MAP)	107.77			107.77			**215.54**	kg/ha
Sulfer fertilizer (Ammonium sulphate)	70.5			70.5			**138.6**	kg/ha
Dry lot manure	93.6	93.6	93.6	93.6	93.6	93.6	**561.6**	kg N/ha
	4195	4195	4195	4195	4195	4195	**25173**	kg/ha
Herbicide application rate (glyphosate)	2.471					2.471	**4.94**	L/ha
Herbicide rate (active ingredient)	1.33					1.33	**2.67**	kg a.i./ha
Diesel use								
Cultivation (1st pass)	4.53						**4.53**	L/ha
Cultivation (2nd pass)	2.36						**2.36**	L/ha
Seeding	2.47						**2.47**	L/ha
Mowing	5.82	11.64	11.64	11.64	11.64	5.82	**58.2**	L/ha
Raking	2.56	5.13	5.13	5.13	5.13	2.56	**25.64**	L/ha
Baling	0.256	0.256	0.256	0.256	0.256	0.256	**1.54**	L/t
	4.138	9.312	10.692	10.692	10.002	6.208	**51.04**	L/ha
Loading and unloading	0.104	0.235	0.27	0.27	0.252	0.157	**1.29**	L/t
	3.465	7.797	8.953	8.953	8.374	5.198	**42.74**	L/ha
Tandem discing (1st pass)						8.46	**8.46**	L/ha
Tandem discing (2nd pass)						6.01	**6.01**	L/ha
Fertilizer broadcasting	2.04			2.04			**4.08**	L/ha
Manure application	Manure application fuel use attributed to cow-calf rather than to hay production							
Spraying	0.84					0.84	**1.68**	L/ha
On-farm transport	0.0284	0.0604	0.0675	0.0675	0.0639	0.0426	**0.33**	L/t
	0.895	2.003	2.297	2.297	2.144	1.331	**10.97**	L/ha
C sequestered	0	2466.2	2405.6	2346.4	2288.7	2232.4	**11739.3**	kg CO_2eq/ha

RESULTS

Table 2. Cradle-to-farm gate energy use and GHG[1] emissions associated with production of 1 tonne of alfalfa-grass hay.

Energy use (MJ)	478
GHG emissions without C sequestration (kg CO_2eq)	141
GHG emissions with C sequestration(kg CO_2eq)	-213

1. GHG emissions are measured as CO_2eq (carbon dioxide equivalents), based on the assumption that over a time frame of one hundred years one kg of N_2O causes the same amount of global warming as 298 kg of CO_2 and one kg of CH_4 causes the same amount of global warming as 25 kg of CO_2.

Energy Use

❑1 tonne of hay = ~1.5 bales = 478 MJ, equivalent to household energy use in ~1.5 days.

❑Diesel fuel use represented 59% of energy consumption.

❑Mowing and baling consumed the most diesel fuel energy (each ~15% of total energy).

❑ Fertilizer manufacture contributed to 34% of total energy consumption (Figure 1).

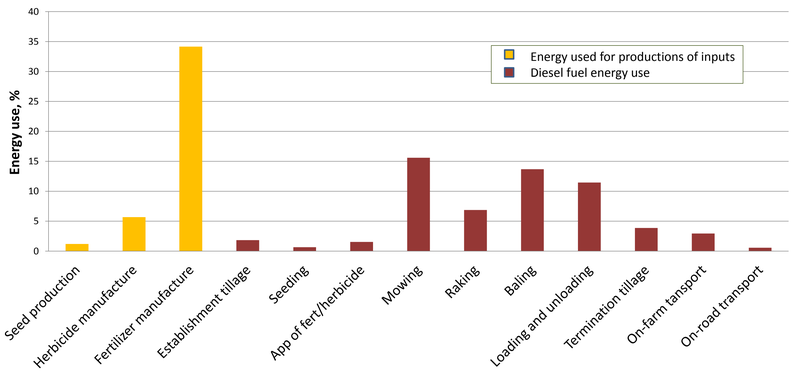

Figure 1. Percentage of total energy use attributed to the main processes of alfalfa-grass hay production in Manitoba.

KEY FINDINGS & RECOMMENDATIONS

❑ **Diesel fuel use represented 59% of energy consumption and 18% of GHG emissions**

- Total diesel fuel use was approximately 4.3 litres/bale.
- Improved fuel efficiency will reduce energy consumption and GHG emissions from hay production.
- Potential areas for improved fuel efficiency may be practicing optimum tractor maintenance, considering less power intensive mower types (e.g. cutter bar-mower conditioners), using net wrap instead of twine to reduce wrapping time, using a skid steer to load bales instead of a tractor, collecting bales with a round bale mover, considering large square balers combined with bale accumulators.

❑**Carbon sequestration estimates indicate that alfalfa-grass hay production may reduce atmospheric CO_2 and the carbon footprint of agriculture; however, uncertainty around sequestration rates is high (+/- 40%)**

- More research on long-term soil carbon dynamics in hay production is needed to reduce this uncertainty.

❑ **Nitrous oxide emissions dominated GHG emissions (70%) during hay production**

- Reducing N input from manure, synthetic fertilizer and crop residues, while maintaining yield will reduce N_2O emissions.
- Reducing harvest losses will reduce N input to soil from hay residues and thereby reduce N_2O emissions. Losses may be reduced by practices that promote rapid drying to avoid weathering, and by practices that reduce leaf shattering.

Greenhouse Gas Emissions and Carbon Sequestration

❑Estimated GHG emissions without C sequestration were 141 kg CO_2eq/tonne of hay.

❑With carbon sequestration GHG emissions were -213 kg CO_2eq/tonne (Figure 2).

❑Carbon sequestration was estimated to be 345 kg CO_2eq/tonne of hay.

❑Large carbon sequestration value is subject to uncertainty (+/- 40%), yet conservative in comparison to recent MB studies:

- 500 kg CO_2eq/tonne of hay (Taylor et al. 2013)
- 800 kg CO_2eq/tonne of hay (Maas et al. 2013)

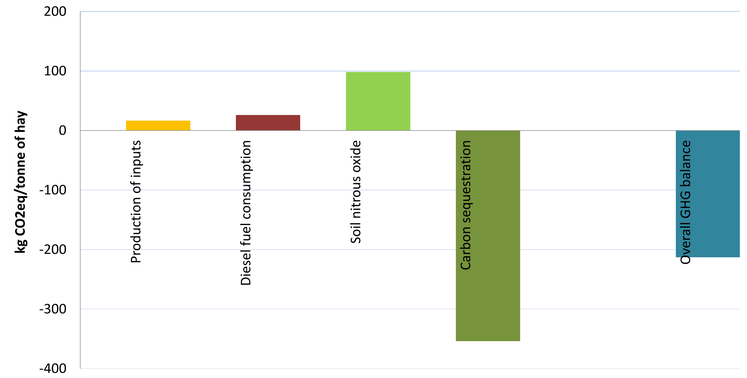

Figure 2. GHG emissions and carbon sequestration kg CO_2eq) associated with production of 1 tonne of alfalfa-grass hay in Manitoba.

Sources of GHG emissions

❑Nitrous oxide (N_2O)from soil contributes 70% of GHG emissions (Figure 3).

❑Diesel fuel use contributes 18% of GHG emissions.

❑Production of fertilizer, herbicide and seed contributes 12% of GHG emissions.

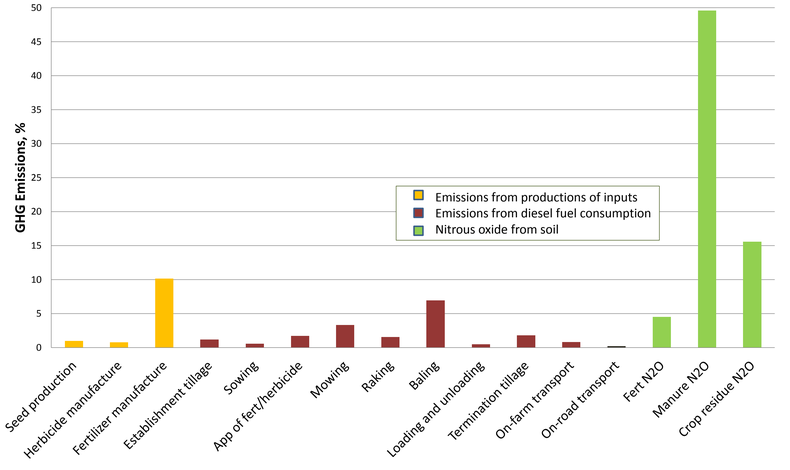

Figure 3. GHG emissions associated with the main processes of alfalfa-grass hay production in Manitoba, excluding soil carbon dynamics.

References: •Mass, S.E., Glenn, A.J., Tenuta, M., Amiro, B.D. 2013. Net CO_2 and N_2O exchange during perennial forage establishment in an annual crop rotation in the Red River Valley, Manitoba. Can. J. Soil Sci. 93: 639-652.•Taylor, A.M., Amiro, B.D., Fraser, T.J. 2013. Net CO_2 exchange and carbon budgets of a three-year crop rotation following conversion of perennial lands to annual cropping in Manitoba, Canada. Agricultural and Forest Meteorology 182-183: 67-75. **Acknowledgements**: GHGm.com, Henry Janzen, Shannan Little, Brian Amiro, Tim Clarke, Lyle Kotyk, Lorne Grieger **Photo credit**: Manitoba Government, Shawn Cabak

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