The role of agricultural recording systems in reducing the global carbon footprint

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Abstract

The effective use of a comprehensive recording and benchmarking system is shown to reduce the overall carbon footprint of agricultural production systems. Dairy producers, research institutions, and allied industry partners collaborating in the U.S. herd recording system (DHI) have demonstrated a 13 percent increase in resource utilization (dry matter intake) and a 15 percent reduction in projected methane production compared to herds not involved in herd recording.

The environmental benefits of herd recording are also interpreted in the context of environmental benefit per DHI worker. While the environmental benefit per cow is no longer increasing over the last ten years, the benefit per worker continues to increase, underscoring the value of herd recording organizations to a national environmental strategy.

Keywords: Herd recording, DHI, carbon, methane, climate change

1.0 Introduction

The U.S. herd recording system (Dairy Herd Improvement or DHI) has grown steadily over its 105-year history due to a strong focus on genetic improvement, reproductive management, mastitis control, and more recently, health and disease management. DHI continued to evolve as new management tools became available, now reaching almost 50 percent of U.S dairy cattle. Over the last 30 years, the full cost of herd recording has been borne by the dairy farmer, with no government subsidies, thus underscoring the value of DHI to the participating farmers. (Table 1)

However, DHI 's sole orientation to date has been towards the profitability of the dairy farmer. Increasingly, U.S. agriculture, including the dairy industry, is coming under the increased scrutiny of environmental groups and federal and local governmental agencies. Environmental stewardship and management of public perception is becoming an important element in farm management.

DHI can serve an additional societal role in reducing the amount of greenhouse gases released under all forms of dairy production, including high-density, conventional, organic, or grazing operations. This paper provides a preliminary view of production metrics recast in an environmental orientation.

Table 1. Enrollment in DHI and DRMS Herd Recording Programs.

Year	All U.S. Cows	DHI Enrollment	DRMS Enrollment
2001	9,102,000 4,	282,206 1,	659,064
2002	9,139,000 4,	226,692 1,	664,236
2003	9,082,000 4,	232,629 1,	864,028
2004	9,011,000 4,	071,099 1,	784,804
2005	9,043,000 4,	121,752 1,	825,864
2006	9,137,000 4,	162,303 1,	811,851
2007	9,189,000 4,	243,205 1,	847,371
2008	9,315,000 4,	414,821 2,	192,080
2009	9,200,000 4,	443,029 2,	201,821
2010	9,085,000 4,	255,950 2,	108,057

2.0 U.S. Perspectives on greenhouse gases

The role of greenhouse gases in climate change is controversial in the U.S and other countries. However, the increase in the level of controversy cannot be avoided. The official position of the U.S. Environmental Protection Agency (EPA) identifies methane of greatest concern:

> *"Methane (CH_4) is a greenhouse gas that remains in the atmosphere for approximately 9-15 years. Methane is over 20 times more effective in trapping heat in the atmosphere than carbon dioxide (CO_2) over a 100-year period and is emitted from a variety of natural and human-influenced sources. Human-influenced sources include landfills, natural gas and petroleum systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial process."*

The regulation of carbon dioxide seems less certain than the focus on methane. The U.S EPA highlights that enteric fermentation and manure management comprised 32.8 percent of methane production in 2008.

3.0 Relative methane production of DHI cows

The mean production of dairy cows (9.1m) in the U.S. in 2006 was 9,048 kg of milk (Economic Research Service, 2006). Forty-nine percent of U.S. cows (4.5m) were involved in formal milk recording schemes defined by the National Dairy Herd Improvement Association (DHI). The mean production of these DHI cows in 2006 was 10,101 kg. Therefore, the production of cows not involved in DHI was 7,989 kg, resulting in a production advantage of 26 percent.

Dry matter intake (DMI) is calculated using the National Research Council, 2001 model.

$$\text{DMI (kg/d)} = (0.372 \times \text{FCM} + 0.0968 \times \text{BW}^{0.75})$$

The relationship of methane production to dry matter intake (Ellis, 2007) is:

$$CH_4 \text{ (Megajoules/d)} = 3.23 + [0.81 \times \text{DMI (in kg/d)}]$$

Applying these DMI and CH_4 models to the DHI production advantage reveals the CH_4 advantage for herds enrolled in milk recording. "Cows Needed" is the number of cows (in millions) required to produce the quantity of milk to meet U.S. consumption and export needs.

Since methane output is derived from dry matter intake, the underlying principle remains the increased production capacity per unit of maintenance. This is clearly demonstrated by the reduced size of the national herd needed as more cows are enrolled in DHI. It should be noted that DHI and non-DHI cows have made significant advances over the last ten years, but the degree of superiority of DHI cows is beginning to shrink.

4.0 Contribution of somatic cell testing and genetic progress

Two significant elements in the effectiveness of DHI have been somatic cell testing and genetic evaluations. Progress has been consistent over the last ten years, as shown in Table 3.

While milk production data are available for non-DHI cows, DHI produces the only national summary of farm performance for SCC and genetic data, and includes only cows enrolled in DHI (AIPL, 2010). One of the few available studies irrespective of DHI enrollment covered the 14 states that shipped at least 60 percent of milk through the Federal milk order system. While a direct comparison against the DHI database is not possible, the rate of improvement over the six-year period is comparable – approximately 12 percent.

Table 2. Relative methane production of a national herd of DHI vs. Non-DHI cows.

	If all cows on DHI recording					If no cows on DHI recording					Relative CH_4 Produced
Year	Milk (kg)	DMI (kg)	CH_4/cow MJ/d	Cows(m) Needed	U.S. CH_4 MJ/d (m)	Milk (kg)	DMI (kg)	CH_4/cow MJ/d	Cows(m) Needed	U.S. CH_4 MJ/d (m)	(%)
1997	24.3	9.75	11.13	7.99	88.92	18.3	8.71	10.28	10.63	109.27	81.37
1998	24.8	9.84	11.20	7.88	88.30	18.4	8.71	10.28	10.64	109.40	80.72
1999	25.4	9.93	11.27	7.95	89.59	19.0	8.80	10.36	10.63	110.05	81.40
2000	25.9	10.02	11.35	8.04	91.21	19.5	8.93	10.47	10.65	111.42	81.86
2001	25.9	10.02	11.35	7.93	90.01	19.5	8.89	10.43	10.55	110.09	81.76
2002	26.4	10.11	11.42	8.02	91.58	20.1	9.02	10.54	10.51	110.80	82.65
2003	26.4	10.11	11.42	8.02	91.65	20.5	9.07	10.58	10.32	109.19	83.94
2004	26.4	10.11	11.42	8.04	91.88	21.0	9.16	10.65	10.09	107.48	85.48
2005	27.2	10.25	11.53	8.10	93.36	21.8	9.30	10.76	10.07	108.37	86.15
2006	27.7	10.34	11.61	8.16	94.71	21.9	9.34	10.80	10.32	111.41	85.01

Table 3. Progress in somatic cell counts and net merit $.

Year	Somatic Cell Count U.S. DHI Cows	Somatic Cell Count Cows in 14-State Federal Milk Order Study
2000	311,000	--
2001	322,000	--
2002	313,000	291,000
2003	319,000	283,000
2004	295,000	265,000
2005	296,000	257,000
2006	288,000	247,000
2007	276,000	258,000
2008	262,000	--
2009	233,000	--

A literature survey (Hortet, 1998) revealed an average daily loss of 0.4 kg in primiparous and 0.6 kg in multiperous cows for each doubling of somatic cell count. This effect contributes approximately 12 percent of the improvement in DHI cows over the ten-year period.

Genetic progress also contributes a significant portion of the ten-year gain. Using data in table 4, this contribution is estimated to be approximately 30 percent. The advent of genomics evaluations will likely have a significant positive effect on the rate of progress. It is likely that DHI data will continue to play an important role in:

Validating the base genomics research.

Continuing to provide evaluation data for traits not summarized in genomics evaluations.

Most significantly, supporting management decisions as the intensity of the decision process increases due to the increased production levels resulting from genomic evaluations.

5.0 Potential contribution of recent developments

Other recent developments are showing strong potential for widespread adoption, and should be evaluated to determine their contribution to the overall effectiveness of the DHI program. These developments include:

Pathogen testing, including Johne's, leukosis and other pathogens.

Advanced management-level analysis tools recently released by the DRMS and AgSource processing centers.

Gender-selected semen.

Table 4. U.S. genetic progress (Indexed to year 2000).

Year	Service Sire Net Merit $ DRMS Holsteins	Sire PTA$ DRMS Holsteins First Lactation	Sire PTA$ DRMS Holsteins All Lactations
2000	324	212	157
2001	341	240	186
2002	362	261	211
2003	369	280	237
2004	398	309	266
2005	423	334	293
2006	422	332	299
2007	438	354	314
2008	472	385	343
2009	517	414	372

6.0 Contribution of DHI organizations and employees

Approximately 800 DHI technicians, field managers, and laboratory staff collect and process data from 14,500 dairy farms enrolled in DHIA Affiliate organizations served by DRMS, at an average monthly cost of EUR 1.42 (US$1.76). This workforce is responsible for the avoidance of 4.25 million megajoules of methane per day (5,300 MJ/d per person), although some consideration should be given to suppliers of milk meters, analyzers, and other components of the milk recording industry.

Using EPA's coalbed methane calculator, 5,300 MJ/d represents 2.0 metric tons CO_2 equivalent per day, or 730 tons per year. The average U. S. citizen produces a CO_2 equivalent of 27 tons. Therefore, the efforts of each DHI worker offsets the carbon footprint of approximately 26 other citizens.

DHI's environmental efficiencies will continue to increase due to new mobile data collection devices, increased analyzer efficiency, additional analyses from the milk sample, and increases in herd size.

6.0 Opportunities

Organizational perceptions can be enhanced by communicating the impact of herd recording on the reduction of greenhouse gasses. While this opportunity may not yield a direct economic benefit, it provides the opportunity to convey the contribution to the community in a significant and documented manner.

Employee relations and the attraction/retention of employees can also be aided by communicating this impact. For example, many employees at DRMS are motivated by the opportunity to strengthen the lives of over 14,000 dairy farm families. The opportunity to contribute to the quality of the global environment can only deepen this employee commitment.

Public funding for marketing and enrollment campaigns may be achieved by providing documented proof of the effectiveness of herd recording.

Measurement of organizational effectiveness can be improved by comparing outcomes in farm performance, including environmental impact. While the superiority of production is still significant under U.S. herd recording schemes, the recent narrowing of this superiority should stimulate a realistic assessment of current and future product development and marketing strategies.

7.0 References

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