Impact of Dairy Herd Reproductive Performance on Predicted Economic Performance, Enteric CH_4 Emission and Excretion of N and P using a Markov-chain Simulation Model

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INTRODUCTION

- Enteric CH_4 emission from ruminant livestock is a contributor to anthropogenic greenhouse gases emission in many countries (FAO, 2006).
- Similarly, excess N and P excretion in manure are important pollutants (NRC, 2003).
- Improving the reproductive performance in high producing cows will result in more milk per total animals in the herd, thus reducing CH_4 per unit of milk, and excretion of N and P in the manure.

OBJECTIVE

- Our objective was to estimate the impact of reproductive performance on predicted enteric CH_4 emission, N and P excretion and economic performance of lactating and dry cows of a dairy herd.

MATERIALS AND METHODS

- A Markov-chain simulation model was used to simulate a 100 cow herd (lactating + dry cows) dynamics based on productive, reproductive, and economic input parameters reported elsewhere (Giordano *et al.*, 2012).
- Different herd structures were obtained after simulation of herds with 12, 14, 20 and 22% 21d-Pregnancy Rate (PR).
- For all scenarios simulated the reproductive management program consisted of a combination of detection of estrus and timed AI (TAI). The synchronization program consisted of Presynch-Ovsynch for 1st AI postpartum and Ovsynch initiated 32 d after the previous AI for second and subsequent AI of those cows not AI after a detected estrus.
- Differences in PR among programs were generated by changing the percentage of cows AI after detection of estrus and their conception rate as well the conception rate of TAI services.
- Lactation curves from a commercial farm in Wisconsin were used to simulate the impact of reproductive performance on farm milk production.
- Dry matter intake (DMI) was calculated based on NRC 2001 empirical equation.
- Enteric CH_4 emission was predicted by an empirical equation (Moe and Tyrrell, 1979) using dietary chemical composition described in Table 1:

$$CH_4\ g/d = [(0.814 + 0.122 \times intake\ NFC\ kg + 0.415 \times intake\ HC\ kg + 0.633 \times intake\ CE\ kg)/0.05565]$$

Table 1. Dietary chemical composition.

	Chemical composition (% DM)				
	CP	NFC	Hemicellulose (HC)	Cellulose (CE)	P
Early (0 to 150 DIM)	16.7	44.2	10.4	16.7	0.38
Late (>150 DIM)	15.4	41.4	11.2	23.0	0.34
Dry period	13.2	34.8	14.3	24.8	0.27

- Manure N and P (g/d) was predicted by mass balance. For dry cows no body accumulation of P and N was assumed.
- Net value ($/cow per d) was calculated by summation of income over feed cost (IOFC), replacement cost, reproductive program cost, and calf value.

RESULTS

Table 2. Predicted animal and economic performance, enteric CH_4 emission and manure N and P excretion.

	Reproductive Program (21-d Pregnancy Rate)			
Item	*12%*	*14%*	*20%*	*22%*
Average DIM lact. cows	188	185	178	176
Lactating cows, %	90.6	90.0	88.6	88.1
3.5% FCM, kg/d	40.3	40.7	41.5	41.8
DMI, kg/d[1]	24.1	24.2	24.5	24.6
Feed efficiency[1]	1.67	1.68	1.70	1.70
IOFC, $/cow per d[2]	7.76	7.78	7.82	7.84
Net value, $/cow per d[2]	7.22	7.26	7.38	7.41
CH_4, g/d[2] per cow	425	423	420	419
CH_4/FCM[2]	11.6	11.6	11.4	11.4
Intake N, g/d[2] per cow	556	556	554	553
Milk N, g/d[2] per cow	185	185	184	183
Manure N, g/d[2] per cow	373	372	370	369
Intake P, g/d[2] per cow	77.8	77.8	77.6	77.5
Milk P, g/d[2] per cow	32.8	32.9	33.1	33.1
Manure P, g/d[2] per cow	45.0	44.9	44.5	44.4

[1]Results expressed on a lactating cow number basis.
[2]Result expressed on a whole herd basis (lactating + dry cows).

- Improving reproductive performance resulted in lower average DIM and percentage of lactating cows, but higher milk production, DMI, and feed efficiency per lactating cow.
- The reproductive management program that generated a 22% PR outperformed the program with 12% PR by $0.19 cow/per d which represents a net gain of $69.4 cow/per year.
- As reproductive performance increased from 12 to 22%, predicted emission of CH_4, CH_4 per unit of FCM, and excretion of N and P decreased by 1.4, 1.7, 1.1 and 1.3%, respectively.

CONCLUSIONS

- Under the simulation conditions of this study, changes in herd structure associated with improved reproductive performance reduced the predicted environmental impact while improving profitability of the simulated dairy herds.
- Future simulation efforts should determine the impact of changes in replacement heifers supply and demand as a result of the resulting reproductive performance on CH_4 emission and N and P excretion from the whole herd.

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