# An integrated approach to nutrient management on dairy farms

**Shabtai Bittman[1], Carson Li[1,3], Derek Hunt[1], Karen Koenig[2], Sean Smuckler[3]**

[1] Agassiz Research Development Centre, Agriculture and Agri-Food Canada, Agassiz, BC, Canada
[2] Lethbridge Research Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB, Canada
[3] Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, Canada.

E-mail: shabtai.bittman@canada.ca

## Abstract

We describe a novel experimental approach to assess the integrated effects of a suite of innovative measures for improving nutrient efficiency of dairy farms. The approach uses four semi-virtual farmlets, representing farm types, that combine field plots (corn and grass) with simulated cattle feeding, enabling integrated assessment of nutrient and crop measures. Our results show overall improved crop nutrient efficiency with targeted use of separated manure fractions and strategic crop management. Cropping measures reduced leaching for both crops but manure measures increased nitrous oxide ($N_2O$) emissions, which was mitigated with a nitrification inhibitor. Results suggest increasing land allocation for corn.

Keywords: nitrogen, integrated whole farm, nitrate, nitrous oxide, crude protein, grass, corn

## 1. Introduction

Animal production is criticised for excessive environmental impact. The dairy industry has increased nutrient efficiency with genetics and feeding but additional measures require assessment in a whole farm context to ensure their efficacy and lack of side-effects (Verloop et al 2015). We use a novel experimental approach to evaluate nutrient and crop measures within four integrated model farm types. The approach employs semi-virtual dairy farmlets combining field plots (corn and grass) with simulated cattle feeding enabling integrated assessment of management measures.

## 2. Materials and Methods

The field experiment was conducted under cool, maritime conditions in British Columbia, Canada. The farmlets represent (F1) local dairy farm with long-season corn and grass (tall fescue) harvested 5X annually; (F2) enhanced manure management with the separated liquid fraction applied as an N source to grass and the sludge fraction precision-applied as P source for corn; (F3) enhanced manure and crop management with short-season corn inter-seeded with winter cover-crop (Italian ryegrass) and longer grass harvest intervals (3 harvests); (F4) advanced measures including irrigation and use of nitrification inhibitor (dicyandiamide, DCD). Nutritional quality of biomass was analyzed and modeled for cow performance.

## 3. Results and Discussion

Separated liquid fraction on grass plus precision-placed sludge fraction on corn (F2) reduced P loading while increasing grass N-uptake (not shown). Manure plus crop management (F3) increased yield, N-uptake and crude protein (CP) concentration compared to reference (F1) (Table 1). Nutrient measures did not alter leaching in either crop but nearly doubled nitrous oxide ($N_2O$) emissions in corn. Cover-crop management greatly lowered nitrate leaching but increased $N_2O$ emissions whereas longer cutting intervals lowered leaching with little effect on $N_2O$. DCD

containing treatments (F4) had reduced $N_2O$ emissions. Based on equal corn and grass land, F4 had greater biomass (1-2 t $ha^{-1}$), N uptake (50-70 kg $ha^{-1}$) and CP (2%) than F1. Allocating more corn land (70%) in F4 increases yield (29%) and N uptake (24%) with little environmental harm compared to reference farm with 40% corn allocation.

The semi-virtual farmlets allowed assessment of complex effects of novel measures which, in combination with increased corn land, improved yield with little environmental impact, freeing land for more homegrown feed. The effect of measures on feed quality and animal performance will be reported. Future work will focus on whole farm modelling.

## 4. Conclusion

Table 1. Effect of farmlet treatments on losses of $N_2O$ and nitrate leaching from grass and corn, and on yield and quality of crops in farmlets with 50:50 land allocation or variable land allocaiton (40:60 corn: grass for F1 versus 70:30 for F2-F4)

| | $N_2O$-N Emission[1] | | | Nitrate Leaching[2] | | | Crop (50:50 land allocation)[3] | | | Crop (modified land allocation)[4] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Farmlet | Corn | Grass | Mean | Corn | Grass | Mean | DM yield | N uptake | CP[5] | DM yield | N uptake | CP[5] |
| | Emission Factor | | | kg $NO_3$-N $ha^{-1}$ | | | t $ha^{-1}$ | kg $ha^{-1}$ | g $kg^{-1}$ | t $ha^{-1}$ | kg $ha^{-1}$ | g $kg^{-1}$ |
| F1 Reference | 0.58 | 0.42 | 0.50 | 106 | 80 | 93 | 15.4 | 222 | 90.2 | 14.4 | 231 | 99.8 |
| F2 Manure | 0.97 | 0.68 | 0.82 | 110 | 82 | 96 | 15.7 | 247 | 98.3 | 17.5 | 226 | 80.4 |
| F3 Manure+Crop | 1.45 | 0.81 | 1.13 | 33 | 53 | 43 | 16.1 | 274 | 107 | 17.0 | 260 | 95.9 |
| F4 Advanced | 0.67 | 0.38 | 0.52 | 23 | 53 | 38 | 17.6 | 300 | 106 | 18.7 | 286 | 95.7 |

[1] Growing seasons only, 2years
[2] One full year
[3] Whole farm based on 50:50 corn:grass land allocation
[4] Variable land allocation (corn:grass): reference (F1) at 40:60 versus F2-F4 at 70:30
[5] Crude Protein

## References

Verloop J, Hilhorst, G J, Pronk A A, Šebek L B, Van Keulen H, Janssen B H and Van Ittersum M K 2015 Organic matter dynamics in an intensive dairy production system on a Dutch Spodosol *Geoderma* **23, 7**159-167