Cornell University
Cooperative Extension

Agronomy Fact Sheet Series Fact Sheet #85

Feasible Whole-Farm Nutrient Mass Balances

Balancing Nutrients on Dairy Farms

Dairy farms can improve profitability and reduce their environmental footprint by evaluating nutrient use efficiency across the farm. The whole-farm nutrient mass balance (NMB) assessment tool can help identify possible areas of improvement and be used to track progress over time. The NMB of a farm is the difference between the amounts of nitrogen (N), phosphorus (P), and potassium (K) imported as feed, fertilizer, animals, and bedding, and nutrients exported via milk, animals, crops, and manure. Nutrient mass balances expressed *per tillable acre* indicate if the farm has the potential to balance nutrients with crop requirements in its land base, while NMBs expressed *per hundred weight (cwt) of milk* indicate how efficiently farms are using nutrients to produce milk. Farms with a larger NMB per cwt are using nutrients less efficiently than those with a lower NMB per cwt. Negative N balances may result in lower crop yields. Negative P or K balances may be desirable in the short-term if a farm has excessive soil test P and K levels, but will reduce crop yields in the long term. In most cases, ideal NMBs are positive (>0), but not excessive.

The first step to analyzing a farm's NMB is to collect information on nutrient imports and exports and entering this information into the NMB software (see Fact Sheet 25 for details). The NMB software produces a report with NMB per acre, per cwt, and some diagnostic indicators. Farmers can compare their farm's NMBs with those of peers with similar farm characteristics. Annual NMB assessments allow farmers to evaluate progress over time.

Distribution of NMBs for New York Dairies

New York dairy farms operate with a wide range of NMB per acre and per cwt, regardless of their size. A study conducted in 2006 with 102 farms showed ranges in NMB per acre from -35 to 211 lbs N/acre, -7 to 45 lbs P/acre, and -45 to 132 lbs K/acre, and ranges in NMB per cwt from -1.3 to 2.6 lbs N/cwt, -0.11 to 0.47 lbs P/cwt, and -0.73 to 1.69 lbs K/cwt. There were high producing dairy farms (>20,000 lbs milk/cow per year) operating with negative NMB as well as farms with very large NMBs, showing that high milk production does not require large nutrient surpluses.

Optimum Operational Zone

While it is clear that neither negative balances nor very large positive nutrient surpluses are desirable, it would be more useful to describe a feasible or optimal operational zone for New York dairies. A feasible NMB should allow dairy farms to be economically profitable and environmentally sustainable while promoting flexibility in management practices. We defined feasible NMBs per acre as being below the point where 75% of the dairy farms in our database were operating in 2006: ≤105 lbs N/acre, ≤12 lbs P/acre, ≤37 lbs K/acre. We also defined feasible NMBs per cwt as those at or below which 50% of the dairies were operating: ≤0.88 lbs N/cwt, ≤0.11 lbs P/cwt, ≤0.30 lbs K/cwt. Combining both indicators, the most efficient and sustainable dairy farms in New York have NMBs in the *optimal operational zone* highlighted in green in Fig. 1. These feasible NMBs are not static and can change over time as more farms join the study, but high producing farms with long-term NMB records have shown it is feasible to consistently operate in this zone over time.

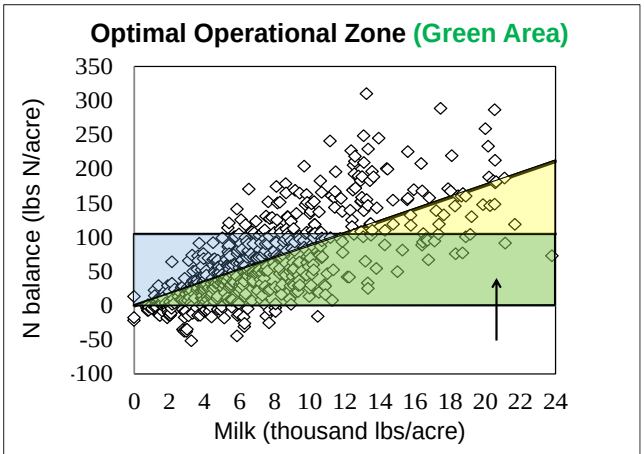

Fig 1: Optimal operational zone based on 102 dairy farms in New York.

Table 1: Indicators that predict the likelihood of exceeding the feasible nutrient mass balances. Comparison with an example farm. Red values indicate potential areas for improvement.

	Nitrogen		Phosphorus		Potassium	
	Farm	High risk	Farm	High risk	Farm	High risk
Balance per acre (lbs/acre)	31	>105	7	>12	-17	>37
Balance per cwt milk (lbs/cwt)	0.24	>0.88	0.06	> 0.11	-0.13	>0.30
Purchased feed (lbs/acre)	125	>121	25	>20	40	>38
Fertilizer (lbs/acre)	19	>39	1	>6	0	>38
Crop exports (lbs/acre)	40	<1	6	<1	36	<1
Manure exports (lbs/acre)	0	<1	0	<1	0	<1
Homegrown nutrients (% DM)	56	<50	47	<50	-	-
Crude protein (CP) and P in all feed (%)	15.1	>17	0.41	>0.40	1.66	-
CP and P in purchased feed (%)	20.0	>30	0.65	>0.60	1.02	-
CP in homegrown feed (%)	12.6	<11.8	-	-	-	-
Feed use efficiency (%)	23	<20	24	<25	11	<11
Whole-farm use efficiency (%)	78	<44	70	<51	142	<39
Animal density (AU/acre)	-	-	1.08	>1.0	-	-
Homegrown feed (% DM)	-	-	66	<62-65	-	-
Overall crop yield (tons DM/acre)	-	-	4.8	4.7	-	-
Milk per cow (lbs/cow/yr)	-	-	26,142	<20,000	-	-

Opportunities for Improving NMBs

Farmers with NMBs in the optimal operational zone are producing milk with high nutrient use efficiencies and a relatively low risk of contributing nutrients to the environment. Farmers whose NMBs fall outside the optimal operational zone may have opportunities for improvement. The indicators in Table 1 can help identify where the opportunities might be. Typically, farms with animal densities >1.0 animal unit (1000 lbs) per acre and farms producing <62-65% of homegrown feed have a high likelihood of exceeding the feasible NMBs per acre. Farms may consider some combination of precision feeding, adjusting fertilizer use, exporting crops (in low animal density farms), exporting manure (in high animal density farms), increasing acreage, and improving crop yield and quality. An example is shown in Fig. 2.

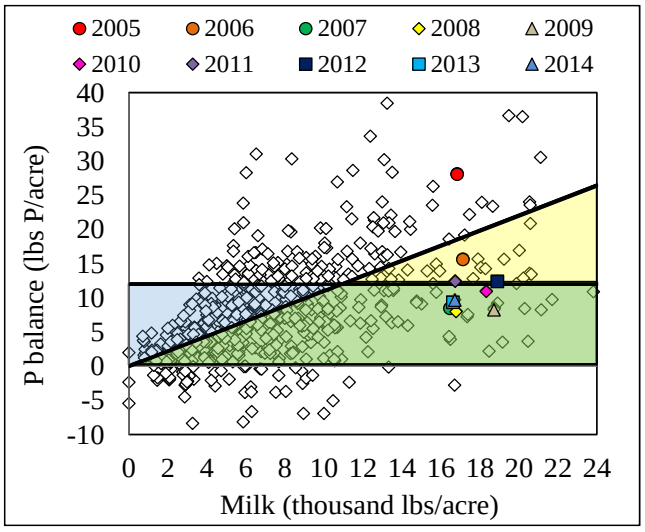

Fig. 2: Farms can operate within the optimum operational zone while maintaining or increasing milk production.

Summary

Farmers with NMBs in the optimal operational zone are producing milk with high nutrient use efficiencies and a relatively low risk of contributing nutrients to the environment. Whole farm NMB indicators can be used to identify potential areas for improvement. The NMBs is also a useful tool to track the impact of management changes on whole farm nutrient use over time.

Additional Resources

- Cornell Nutrient Management Spear Program Agronomy Fact Sheet 25 (Whole Farm Nutrient Mass Balance): http://nmsp.cals.cornell.edu/guidelines/factsheets.html
- For help assessing a NMB and interpreting the results, contact Quirine Ketterings, Nutrient Management Spear Program, 323 Morrison Hall, Cornell University 14853.

Disclaimer

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

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