Yield Records for Adaptive Management on Dairy Farms: A Case Study Approach

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ABSTRACT

With increasing costs of production, fluctuating milk prices and the need to feed a growing population while also reducing the environmental footprint, it has become increasingly important to gain efficiencies in nutrient use on both a whole farm and field by field basis. Work with case study farms in New York over the past five years has shown that great improvement can be made in nutrient use efficiency when detailed farm, feed, and field records are kept. To achieve the nutrient reductions and increased efficiencies, accurate farm and field yield records are essential. Experience to date has shown that accurate yield records are *the* major bottleneck on many farms for diagnosing causes of high nutrient balances, identifying solutions, designing rotations that feed the cows in a sustainable way, and confidently managing nutrients on a field by field basis. Because home-grown forage and grain production impact all aspects of the farm (economics, nutrient use, environmental footprint, risk management, cost of production), without accurate yield records, it is nearly impossible to systematically measure progress at the field level, much less identify where the largest nutrient use efficiency gains can be made. Thus, accurate yield records are needed. This study used a New York dairy farm as a case study to evaluate yield records over twelve years and document changes made by the farm relative to nutrient management and their environmental footprint, as a result of yield record keeping and management.

INTRODUCTION

- Adaptive Management is defined by the NEERA1002 Coordinating Committee on Adaptive Management as "*an on-going process of developing improved management practices for efficient production and resource conservation by use of participatory learning through continuous systematic assessment*."
  - The process requires use of systematic assessment tools.
  - Those tools can include on-farm trials with yield measurements, as well as annual whole farm nutrient mass balance assessments.
- Measuring yield on dairy farms can help:
  - Identify productive versus non-productive fields, allowing for better allocation of nutrients and other management decisions.
  - Determine crop removal of phosphorus (P), important for Concentrated Animal Feeding Operation (CAFO).
  - Improve inventory estimates of farm-produced forages allowing for better nutrition management and evaluation of storage losses.
  - Implement on-farm research that evaluates alternative management practices.
- Dairy farms in NY produce almost all their own forages including alfalfa, grass and corn silage.
  - Forage production impacts every aspect of the farm. To enhance profitability and minimize environmental loss of nutrients, it is essential to evaluate forage yields and production.
- Accurate yield records need to be kept to evaluate progress and document changes on a field-by-field and a whole farm basis.
  - Currently, not many dairy farms conduct yield measurements.
  - With development of more accurate forage yield monitors, more farms will have an ability to collect yield data without the extra labor investment of using on-farm scales to measure each truck load.

OBJECTIVES

- Evaluate the benefits of measuring yield to identify:
  a. Highly productive, stable fields,
  b. Underlying soil properties as potential causes for yield and stability performance,
  c. Impact of average corn silage yield on annual whole farm mass balances.

Figure 1: Forage harvester preparing to harvest a field of corn silage.

Figure 2: Truck of silage being weighed using an on-farm scale.

MATERIALS AND METHODS

- A case study dairy farm was selected in Wyoming County, NY, located in the western part of the state.
- **Farm Characterization:**

Table 1: Parameters for the 2012 growing year or a case study dairy farm in western NY.

Parameter	Value
Area of tilled land	635 hectares
Area of corn silage	316 hectares
Area of alfalfa and grass hay	208 hectares
Numbers of milking cows	1044 cows
Number of calves and heifers	842 cows
Animal density†	3.04 animal units/ha
Milk produced	12,883 kg/cow/year

†One animal unit is defined as 454 kg.

- **Yield Data:**
  - Corn silage yield data were recorded for 105 fields from 2000 through 2012 (2006 data missing).
  - On-farm scales were used to determine individual field yields for each year in corn silage production, and overall field averages and coefficient of variation (CV) were calculated (Figures 1 and 2).
  - Field characterization data were collected for each field on the farm including soil test data (nutrient, organic matter, pH), soil type, drainage, manure and fertilizer history.
  - Fields were characterized into four quadrants based on average yield (below or above average) and coefficient of variation.
    - Soil properties of seven fields that produced above-average yields consistently (CV<10%) were compared to properties of seven low producing fields with high CV's.
    - Two sample t-tests were used to compare soil properties.
- **Nutrient Mass Balances:**
  - Cornell University's Nutrient Mass Balance calculator was used to calculate mass balances for nitrogen (N), P, and potassium (K).
  - Mass balance data were collected between 2005 and 2012 and included values related to:

Farm Imports	Farm Exports
• Feed • Animals	• Milk • Crops
• Fertilizer • Bedding	• Animals • Manure

  - Balances were calculated as the difference between imports and exports (N, P, K) on an annual basis, divided by total tillable area.

RESULTS

Yield Data:

- The average corn yield for all fields and years was 15.4 Mg DM/ha.
  - The highest yielding field averaged 19.1 Mg DM/ha (5 years of data) versus 11.3 Mg DM/ha (6 years of data) for the lowest yielding field.
- Yields in 2000-2003 averaged 13.4 Mg/ha versus 16.4 Mg/ha in 2010-2012 (Figure 3).
- The farm's average CV was 16%. Of all fields, 19% had a CV <10% with average yields ranging from 12.5 to 19.1 Mg/ha (Figure 4).

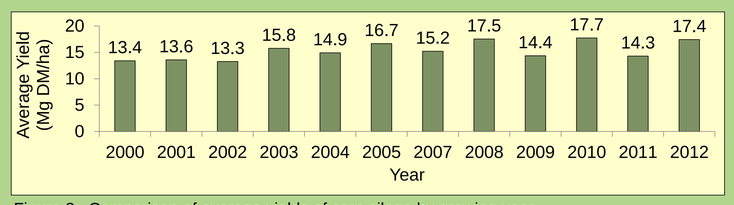

Figure 3: Comparison of average yields of corn silage by growing year.

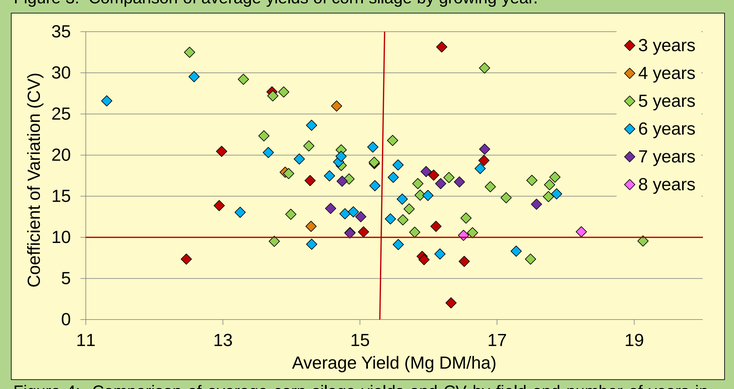

Figure 4: Comparison of average corn silage yields and CV by field and number of years in production over a 12 year period during which individual yield data were collected.

RESULTS

- The subset of fields in two quadrants had significant differences in several soil parameters including P and Mg (Table 2).

Table 2: Comparison of soil parameters between a subset of 7 fields that are high yielding-low variability and low yielding-high variability.

Parameter	High Yield- Low Variability	Low Yield- High Variability	P-value
Average Yield (Mg DM /ha)	16.9	13.0	<0.0001†
CV	7.4%	27.3%	<0.0001†
pH	6.8	6.8	0.6947
Organic Matter (%)	3.3	2.9	0.0910
Morgan P (mg/kg)	17.6	11.8	0.0308†
Mehlich-3 P (mg/ha)	70.9	40.1	<0.0001†
Mehlich-3 K (mg/kg)	126	99.0	0.1096
Mehlich-3 Mg (mg/kg)	182	229	0.0278†
Mehlich-3 Ca (mg/kg)	1666	1913	0.1611

†Indicates a significant *P*-value at 0.05.

Nutrient Mass Balance Data:

- The whole farm nutrient mass balance decreased by 37% for N, 52% for P and 57% for K (Figure 5).
- Cow numbers, tillable area, animal density remained the same.
- Farm produced forage remained at 68% throughout the period.
- Fertilizer imports decreased by 12.5 kg N/ha (63%), while P increased by 2 kg/ha (47%) and K decreased by 40 kg/ha (75%).
- Feed imports decreased by 21% N, 38% P and 38% K.
- Milk production increased by 16%, thus increasing exports in milk.

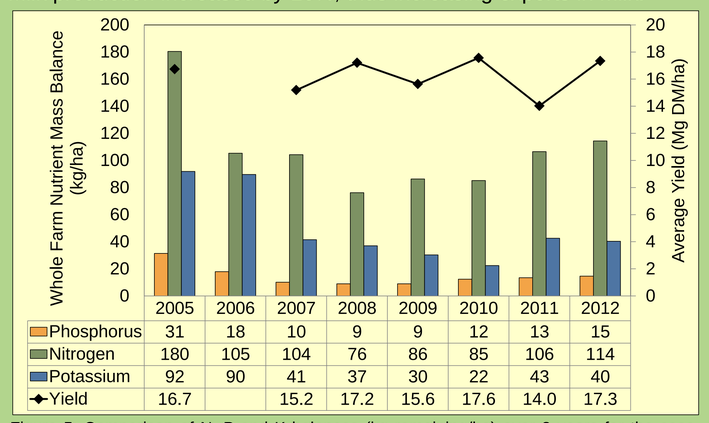

Figure 5: Comparison of N, P and K balances (kg remaining/ha) over 8 years for the case study farm and average corn silage yield for each year the mass balance was completed.

CONCLUSIONS

- The average yield for the first three years was lower than the average for the last three years.
- A subset of fields in different quadrants of yield and variability revealed differences in several soil parameters, but further work needs to be conducted to evaluate drivers for the differences.
- The overall reduction in N, P and K balances came from a reduction in N, P and K imports, specifically related to feed imports and milk production.
  - Percent farm produced forage in the diet remained constant, consistent with farm average corn yield.
- This farm is an example of how diligent record keeping, particularly of yields, combined with conducting an annual nutrient mass balance can result in improvements in nutrient use over time.

FARMER TESTIMONY

"Accurate yield data is the basis for many important decisions on our farm. Knowing our haylage and corn silage inventory allows us to make year round feeding plans as well as to better determine next year's cropping needs and rotations. Years of yield data on individual field helps us determine the success of various cropping decisions, including seed selection, tillage methods and nutrient application. And, by knowing our inventories, we can more accurately determine the financial value of our farm when participating in bench mark studies or transferring ownership."

ACKNOWLEDGMENTS/CONTACT INFO

This work was supported by a NRCS Conservation Innovation Grant. We thank our participating case-study farm for providing many years of data. For questions about these results contact Emmaline Long at eal93@cornell.edu, or Quirine Ketterings at qmk2@cornell.edu. Visit the Cornell Nutrient Management Spear Program website at: http://nmsp.cals.cornell.edu/ for more information.