UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

UC ANR Publication 8715 | June 2022
https://doi.org/10.3733/ucanr.8715
https://anrcatalog.ucanr.edu

UC PEER REVIEWED

Methods for Collecting Representative Samples of Solid Manure for Nitrogen Analysis

CHRISTINE MILLER, Postdoctoral Researcher in the Department of Animal Science at UC Davis;

DEANNE MEYER, Livestock Waste Management Specialist in the Department of Animal Science at UC Davis;

JENNIFER HEGUY, UC Cooperative Extension (UCCE) Dairy Advisor in Merced, Stanislaus, and San Joaquin counties;

BETSY KARLE, UCCE Dairy Advisor in the Northern Sacramento Valley;

PATRICIA PRICE, Staff Research Associate in the Department of Animal Science at UC Davis

Dairy farmers often apply solid manure to their forage crops. Manure nitrogen, phosphorus, and potassium provide nutrients (fertilizer) and organic matter improves soil health. Applying too little nitrogen to crops can stunt crop yields, while applying too much can have negative effects on groundwater quality. To prevent the latter, regulations from the Central Valley Regional Water Quality Control Board limit the amount of nitrogen that can be applied to cropland (CVRWQCB 2007, 2013).

Theoretically, farmers can meet both environmental and yield goals by maximizing the proportion of applied nitrogen that is taken up by crops. Planning precise applications requires accurate measurements of the dry-matter and nitrogen concentrations of manure applied to cropland. These data are used in conjunction with quantity of manure applied to calculate nitrogen application rates. Each farmer must collect a representative sample of each source of manure for analysis because manures vary greatly depending on farm-specific factors. Representative samples are the basis for sustainable cropland management, fair pricing for manure exports, and defensible regulatory reporting.

There is little verified information about how farmers typically sample their solid manure. Most solid manure is stored in static piles before it is applied to cropland. Recommended sampling protocols typically suggest collecting a few grab samples (around ten) from different locations in the pile. The grab samples are mixed to form a composite. The dry-matter and nitrogen analyses of the composite are then used to calculate the nitrogen application rate (Davis et al. 2002; Dou et al. 1997; Meyer and Mullinax 2011). The number and location of grab samples collected from the pile can affect the accuracy of nitrogen application rates based on the composite analysis.

In this study, we establish the accuracy of practices for collecting samples of solid manure to represent the dry-matter and nutrient composition of the pile. We undertook a detailed research project to identify variability both within and between solid manure piles. Ten piles of dairy manure were sampled, in six to ten locations and at 8-inch increments, from the surface inward to a depth of 4 feet. Using data from these samples, we compared sampling practices in which different numbers of grab samples were collected from different locations in the pile (Miller et al. 2019).

Number of grab samples

It is important to consider the history and source of the manure pile when deciding how many grab samples are necessary. Intuitively, collecting more grab samples should lead to a more representative composite sample. To accurately represent the pile composition, piles that contain manure from multiple sources require more grab samples than piles from a single source.

The error in the nitrogen application rate was less than ±15 percent of the calculated mean rate when five grab samples were collected from single-source piles, while ten grab samples were required to keep the error rate

below 15 percent for multisource piles (fig. 1). Five single-source piles and five multisource piles were included in our study. Single-source piles were composed of manure from a single cattle group or solid separator and were constructed during a single piling event. More grab samples were required when a pile contained manure from several cattle groups or included spoiled feed or bedding. When manure was added to a pile over time, the pile was also considered multisource. Without information about the pile source, our data suggest that ten grab samples are required to accurately represent the manure pile.

To put the possible error into context, consider a farmer who aims to apply 100 pounds of nitrogen per acre as solid manure. This farmer collects five grab samples for the dry-matter and nitrogen analysis and uses the results to calculate how much manure to apply.

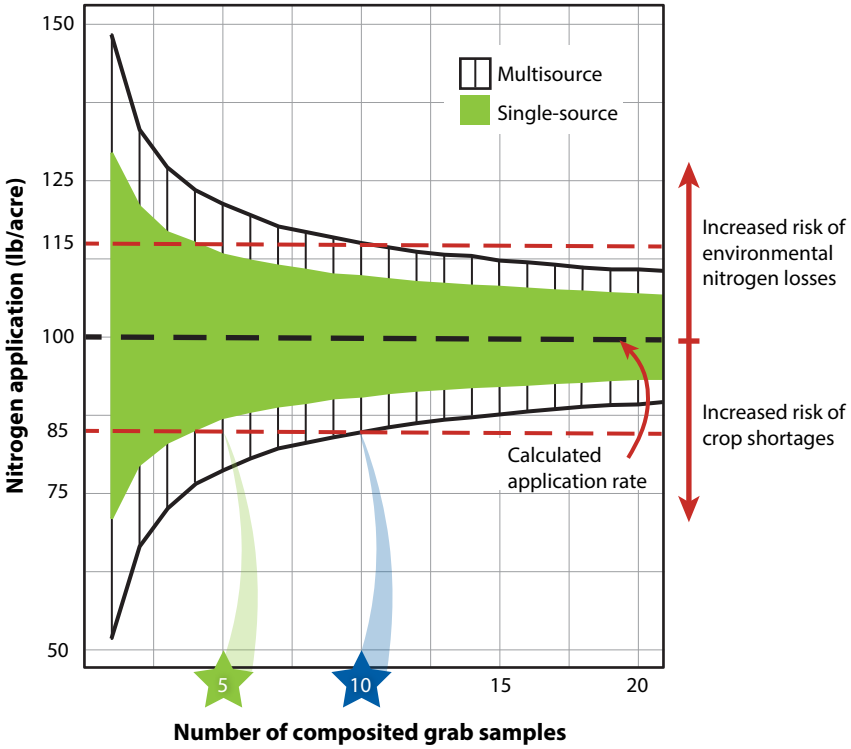

Figure 1. Recommended number of grab samples depends on the composition of the manure pile. The graph compares the possible error in the nitrogen application rate for single-source and multisource solid-manure piles, based on our field experiments. To calculate the error in the nitrogen application rate, we assumed the farmer intended an application rate of 100 pounds of nitrogen per acre. The starred numbers identify the number of grab samples needed to ensure that the actual application rate is within ±15 percent of the intended rate (red dashed lines) for single-source and multisource manure piles.

If the farmer's pile is composed of multiple sources of manure, the actual application rate could be off by ±21 pounds of nitrogen per acre. By comparison, if the farmer's pile is from a single source of manure, the actual application rate could be off by ±13 pounds of nitrogen per acre, a much smaller error (see fig. 1). For a multisource pile, the farmer would need to collect ten grab samples to be sure the actual application rate was within ±15 pounds of nitrogen per acre of the calculated rate (see fig. 1).

Measurement practices that underestimate the nitrogen application rate increase the risk of environmental nitrogen losses. On the other hand, measurements that overestimate nitrogen application rate may reduce crop yields. Additionally, overestimating the nitrogen application rate increases the nitrogen ratio (applied nitrogen divided by nitrogen harvested) reported to regulatory agencies. Collecting the appropriate number of grab samples from solid manure piles improves the efficiency of manure nutrient use and reduces impacts on groundwater quality.

Sampling locations

Representative samples should reflect any differences between the interior and exterior of the pile. Manure piles are often drier on the exterior because of exposure to the sun and wind. Among the studied piles, exterior samples had a dry-matter concentration 4 percent higher than the interior samples, on average. Because nitrogen concentration is reported as a percentage of dry matter, any error in dry-matter measurement is reflected in the nitrogen measurement. Accordingly, the calculated nitrogen application rate will overestimate the actual application rate by up to 24 percent if too many samples are collected from the exterior.

To avoid consistently over- or underestimating dry-matter concentration, 80 percent of grab samples should be collected from the pile interior, defined as deeper than 1.5 feet into the pile (fig. 2). To put the possible error into context, again consider a farmer who calculates an application rate of 100 pounds of nitrogen

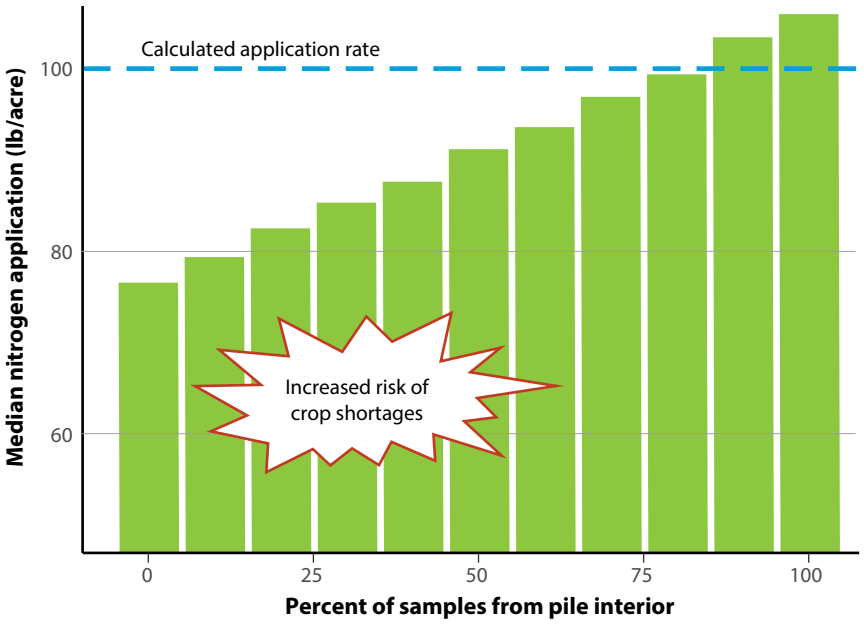

Figure 2. Recommended protocol for sampling solid manure piles. We recommend taking a composite of at least ten samples, 80 percent of which are deeper than 1.5 feet into the pile. Following this protocol ensures that the calculated nitrogen application rate will be within 15 percent of the actual application rate, regardless of the pile's source. Measurement error depends on the location of grab samples. Samples from the exterior 1.5 feet of the pile are typically drier than interior samples. The bars show the possible error in the calculated nitrogen application rate when different percentages of samples are collected from the pile's interior.

per acre based on an analysis of dry matter and nitrogen. If all grab samples are collected from the exterior of the pile, the composite sample will be drier than the actual composition of the pile as a whole. Consequently, the calculated application rate will overestimate the actual rate by 24 pounds of nitrogen per acre, and often more (fig. 3). Consistently overestimating nitrogen application rates is likely to reduce crop yields and to overestimate the nitrogen ratio reported to regulatory agencies.

Recommended sampling practices

Managing nitrogen requires attention to sampling practices. This and other research shows that dairy farmers can substantially improve their nitrogen management plans by incorporating the following practices for sampling solid manure:

- Collect ten grab samples from the pile (if the pile is from a single source of manure, five samples are acceptable).
- Collect 80 percent of grab samples from greater than 1.5 feet into the pile.
- Sample at a time close to when manure will be applied.
- Follow proper sample-handling protocols to obtain quality results from laboratory analysis.
- Consider the accuracy of your practices for weighing the applied manure.
- Maintain appropriate records of manure applications.

This project clarified the importance of adapting sampling practices to manure storage practices (single-source versus multisource). Our study also showed it is necessary to accurately represent the differences between the interior and exterior of the pile in the composite sample. Improved sampling practices and quality recordkeeping can produce better estimates of nitrogen applied to fields or manifested off-farm. Better management of nitrogen in solid manure will lead to sustainable crop yields, reduced impact on groundwater quality, and defensible regulatory reporting.

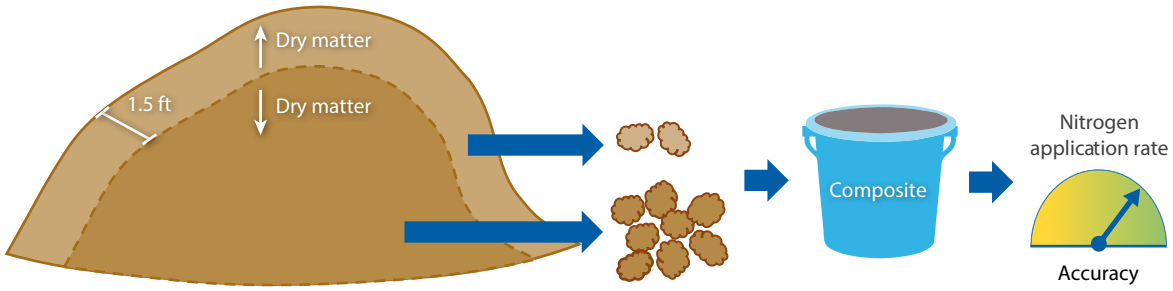

Figure 3. Collect 10 grab samples, mix well, and subsample for each composite. Take 80 percent of samples from more than 1.5 feet into the pile. Following this protocol ensures that the calculated nitrogen application rate will be within 15 percent of the actual application rate, regardless of the pile's source.

For more information

More information on regulatory requirements for sampling and reporting in the Central Valley can be found in the Monitoring and Reporting Program and Technical Guidance for Nutrient Management Plans in the Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies, waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/.

Information on many aspects of dairy-manure nutrient management and water quality compliance is available in the Dairy Quality Assurance Program Central Valley Dairy General Order Water Quality Reference Binder, cdqap.org/binders/central-valley-water-quality/.

For more information on the methods and results of this study, see Miller et al. (2019), ncbi.nlm.nih.gov/pubmed/30803565.

Acknowledgements

Support for this research came from the W.K. Kellogg Endowment; the McComie Endowment for graduate student support; the UC ANR Agricultural Experiment Station; and the Austin Eugene Lyons Graduate Fellowship. We sincerely thank cooperating farmers and gratefully acknowledge the infrastructure support of the Department of Animal Science and the College of Agricultural and Environmental Sciences at UC Davis.

References

(CVRWQCB) Central Valley Regional Water Quality Control Board. 2007. Waste discharge requirements general order for existing milk cow dairies. Order No. R5-2007-0035, Central Valley Region 5. https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2007-0035.pdf

(CVRWQCB) Central Valley Regional Water Quality Control Board. 2013. Reissued waste discharge requirements general order for existing milk cow dairies. Order No. R5-2013-0122, Central Valley Region 5. https://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2013-0122.pdf

Davis, J. G., K. V. Iversen, and M. F. Vigil. 2002. Nutrient variability in manures: Implications for sampling and regional database creation. Journal of Soil and Water Conservation 57(6):473–478. https://www.jswconline.org/content/57/6/473

Dou, Z., D. T. Galligan, R. D. Allshouse, J. D. Toth, C. F. Ramberg Jr., and J. D. Ferguson. 1997. Manure sampling for nutrient analysis: Variability and sampling efficacy. Journal of Environmental Quality 30(4):1432–1437. https://doi.org/10.2134/jeq2001.3041432x

Meyer, D., and D. Mullinax. 2011. Solid manure sampling protocol. In CDQAP-WDR General Order Reference Binder. California Dairy Quality Assurance Program.

Miller, C. M. F., J. M. Heguy, B. M. Karle, P. L. Price, and D. Meyer. 2019. Optimizing accuracy of sampling protocols to measure nutrient content of solid manure. Waste Management 85:121–130. https://doi.org/10.1016/j.wasman.2018.12.021

To order or obtain UC ANR publications and other products, visit the UC ANR online catalog at https://anrcatalog.ucanr.edu/ or phone 1-800-994-8849. Direct inquiries to

UC Agriculture and Natural Resources
Publishing
2801 Second Street
Davis, CA 95618
Telephone 1-800-994-8849
E-mail: anrcatalog@ucanr.edu

Publication 8715

ISBN-13: 978-1-62711-204-8

To simplify information, trade names of products have been used. No endorsement of named or illustrated products is intended, nor is criticism implied of similar products that are not mentioned or illustrated.

An electronic copy of this publication can be found at the UC ANR catalog website, http://anrcatalog.ucanr.edu/.

UC PEER REVIEWED

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by UC ANR Associate Editor for Agronomy Sciences Daniel H. Putnam.

web-6/22-LC/SO