HAPPY COWS, HAPPY ENVIRONMENT: IT'S THE MANURE
Integrating dairy manure water nutrient use with forage production

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INTRODUCTION

Revisions to county, state, and federal requirements for manure nutrient management have resulted in restrictions on dairy establishment and expansion in a number of California counties. The development of county-wide EIRs (Environmental Impact Reports) for dairies has increased the requirements for dairy producers to manage manure nutrients in a manner that is environmentally sustainable and does not release excess nutrients to surface and ground water or to the atmosphere as ammonium. Several industry and government initiatives are in progress to assist dairy operators in improving dairy manure management systems and to educate individual dairy operators, crop advisors and consultants, and NRCS and Cooperative Extension personnel about these techniques.

One such initiative is a Biologically Integrated Farming Systems (BIFS) project funded by the UC Sustainable Agriculture and Education Program (SAREP) entitled "Integrating forage production with dairy manure management in the San Joaquin Valley". Started in the summer of 1999, this project is a collaborative effort by UC Cooperative Extension staff and 11 dairies in Tulare, Fresno, Merced, Stanislaus, and San Joaquin Counties. UCCE advisors and specialists are working with the cooperating dairies – which were selected because they already were using some improved methods – to adopt a more complete package of practices to control and limit application of manure nutrients to forage crops.

The goals of the Dairy BIFS project are to reduce reliance on commercial fertilizer, and to balance manure nutrient application with forage crop nutrient requirements and uptake capacity. Forages include silage corn, winter forage grasses, sudangrass, alfalfa, and berseem clover.

The focus of this project is on the liquid portion of the collected "waste" in flush dairy systems. Expansions of California dairies and improvements, such as adoption of freestall housing and flush lanes, result in further direction of manure nutrients into the liquid rather than solid form. Therefore, the proportion of excreted manure nutrients in a dairy's liquid storage system can reach 90% or more, depending on animal housing and the manure collection system. Additionally, liquid manure is more difficult than solid manure to export to distant fields or to other uses, such as composting. As the economics of dairy farming have pressured farmers to increase herd size, manure-handling systems need to be scaled up or even completely redesigned. Often this has not been done. It would be a challenge even without the prospect of increasing regulatory requirements.

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THE IMPROVED MANAGEMENT SYSTEM

Many California dairies have increased or are planning to increase manure water storage pond volume, and are purchasing or improving the access to additional crop acreage for manure utilization. For whole farm management, these will often be necessary steps in order to ensure application of nutrients on a growing crop at rates that can be utilized within a reasonable time period. Beyond these capital investments, management of manure nutrients requires a system that allows for monitoring and planning of nutrient application rates.

The system utilized by BIFS project dairies includes measurement of flow and nutrient content of manure water during application to crops through the irrigation system. All participating dairies have purchased or borrowed specialized flow meters—in most cases, a permanent magnetic flow meter—to measure liquid manure outputs during irrigations. A sample of the manure water is collected from a sampling valve or the outlet to the standpipe and analyzed for ammonium nitrogen (N), organic N, total phosphorus (P), and total potassium (K). An on-farm quick test for ammonium N has been developed to enable targeting of application rates in order to achieve a specified N application rate. The samples are sent to an analytical laboratory for the other analyses. Using a computer spreadsheet or a paper worksheet and tables, growers are then able to calculate N, P, and K application and adjust manure water application rates to meet the crop needs and no more.

A list of possible improvements to dairy manure management systems has been compiled following conversations with dairy producers and other advisors (Table 1). This list is also based in part on testing of systems on commercial dairies in Merced and Stanislaus County under the leadership of Marsha Campbell Mathews, UCCE Farm Advisor. Some of the improvements are currently supported by the BIFS project and others are being utilized through grower initiative.

Table 1. System components for improving dairy manure water nutrient management. This is not a complete list, nor are all of these required at any one dairy.

Practices	Supported by BIFS project
Manure water flow measurement and control	♦
Manure water nutrient analysis for calculating application rates	♦
Dilute manure water or apply smaller amts in each irrigation	♦
Use manure water on alfalfa	♦
Soil and plant tissue analysis	♦
Separate more manure solids before irrigating	
Irrigation system improvements	
Alterations to forage crop rotation	♦

CORN/WINTER FORAGE ROTATION

In 2000, each project dairy established a demonstration to compare “conventional practices” with improved practices on large, field-size plots. Practices were variable, but improved practices tended to involve lower applications of commercial fertilizer and/or manure water nutrients. Nutrient (N, P, and K) application in both commercial fertilizer and manure was measured and

recorded and nutrient uptake was monitored for all crops on the project fields. Measurements were also taken during 2001 and will again be collected through the summer of 2002. By 2001, managers or irrigators at most of the project dairies were recording manure water flow volume and collecting samples. The goal is for project dairies to complete development of a system that can be continued with minimal involvement from university personnel when the BIFS project is ended.

Measuring manure nutrient application enabled growers to make more informed commercial fertilizer decisions. They felt more comfortable reducing commercial fertilizer use once they knew that the crop nutrient needs were being met by the nutrients in the manure. Therefore, commercial fertilizer applications on BIFS fields have nearly stopped, with six of the eight silage corn/winter forage participants completely eliminating commercial fertilizer N, and all eight eliminating fertilizer P and K (Table 2). Commercial fertilizer is not used on the BIFS fields at the two alfalfa/alternative winter forage sites either, although this is common practice for alfalfa production. Yield measurements of the reduced commercial fertilizer plots have shown excellent yields equal to other treatments (Table 3), and growers have indicated a desire to continue growing forage crops with manure as the sole plant nutrient source.

Table 2. Commercial fertilizer nutrient applications on silage corn at BIFS dairies project fields before the BIFS project (left) and during the second season of the BIFS project (right). Manure water was applied in both situations.

Dairy	N	P_2O_5	K_2O
1	100	78	0
2	71	25	25
5	150	10	0
6	200	100	150
7	40	0	0
8	80	91	119
10	150	0	0
11	100	0	0

Dairy	N	P_2O_5	K_2O
1	0	0	0
2	0	0	0
5	0	0	0
6	125	0	0
7	0	0	0
8	30	0	0
10	0	0	0
11	0	0	0

Table 3. Silage corn yields (shown in tons/acre @70% moisture) did not decrease when BIFS dairy farmers reduced application rates of N fertilizer or manure.

	2000		2001	
Dairy	**Conventional**	**Reduced**	**Conventional**	**Reduced**
1	21.7	22.7	23.9	24.8
2	25.1	29.8	29.6	27.6
4	23.0	20.2	N/A	N/A
5	N/A	N/A	26.1	26.8
6	26.8	27.2	30.9	32.2
7	29.6	29.9	32.6	30.2
8	28.0	28.9	28.9	30.1
10	N/A	24.4	25.7	25.7
11	35.1	32.1	34.9	34.9

Some dairies are targeting manure application for each irrigation based on crop N needs, viewing the manure pond as a fertilizer tank. The targets are specific to whole fields, or even to individual border checks, depending on the amount of management time dedicated. Because silage corn in the Central Valley often receives 6 to 10 irrigations, growers have flexibility to achieve seasonal targets by cutting back on manure water if they overshot the target on an earlier irrigation as shown in Fig. 1.

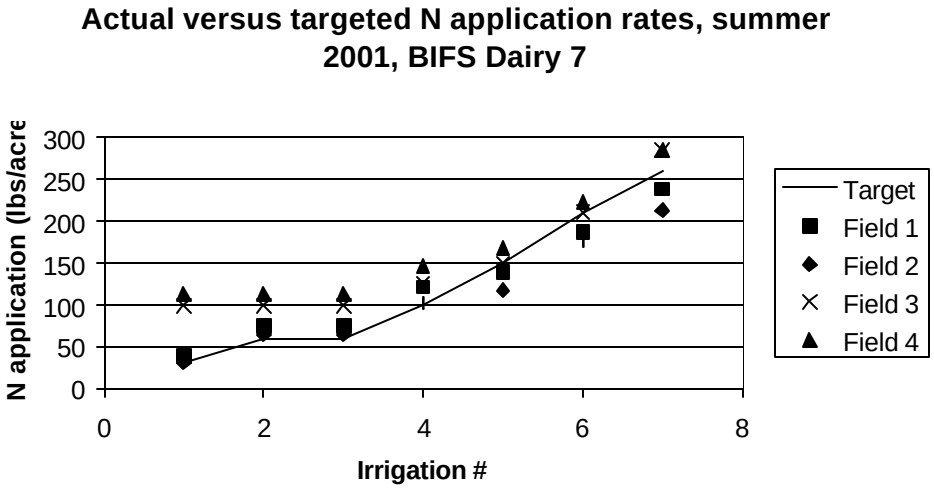

Fig. 1. Cumulative N application to silage corn in manure water over 7 irrigations. Target amounts were determined by grower in consultation with county farm advisor and BIFS project coordinator.

USING MANURE WATER ON ALFALFA

Application of manure water to alfalfa has been limited due to problems noted with scald, buildup of organic solids in the field, and increased weed pressure. However, a large portion of the land area surrounding dairies and accessible to manure water, especially in the south San Joaquin Valley, is planted to alfalfa. If alfalfa can be used as a recipient for manure water, the land area available for this manure water utilization could be increased significantly. Alfalfa has the ability to remove large amounts of N, P, and K from the soil reserves, and so has the potential to utilize substantial manure nutrients. The need for P and K fertilizer in alfalfa can also be met with nutrients in the manure. Deep-rooted alfalfa can also reduce nitrate leaching by capturing nitrate that has traveled below the root zone of other crop plants.

The problems with solids buildup and weed seeds can be addressed to varying degrees with settling basins and other solids separation systems. Removal of organic material in the manure water also reduces biological oxygen demand and competition with the alfalfa crop for that oxygen. The risk of scald can also be decreased by applying manure water to alfalfa during spring and fall, instead of in the summer when hot temperatures stress the plant and make it more susceptible to reduced available oxygen in the soil.

Application of manure water to alfalfa on BIFS sites has resulted in no yield or quality differences compared to non-manured treatments. The application of manure water was limited

to spring and fall, and the manure water was diluted with fresh irrigation water so that each irrigation applied no more than 75 lbs N/acre (also resulting in low salt levels). Solids content in the manure water was reduced by settling manure in one pond before transfer to the final pond.

CHALLENGES TO IMPROVED MANURE MANAGEMENT

California dairy producers are faced with a number of challenges that limit the implementation of improved manure management and are not directly addressed by the BIFS project. These challenges must be met by dairy producers themselves or through other cooperative efforts. These include 1) insufficient storage capacity, resulting in manure application based on pond capacity instead of crop needs, 2) insufficient fresh water supply, in winter or year-round, for dilution of manure water, so application rates end up being higher than crop needs, and 3) fresh water coming from different sources, such as wells, making appropriate mixing of manure and fresh water difficult, and requiring some significant pipeline changes.

Attitudes and values of dairy producers, their crop consultants, farm managers, and farm workers may require some changes in order to adapt to the new perspective on dairy manure as a resource rather than a waste in need of disposal. Additionally, the common practice of distributing nutrient applications in very large amounts few times per year must be changed to smaller applications that better match crop needs. These changes will take time to become established, but as has been noticed with Dairy BIFS participants, producers embrace new practices once they realize both their economic and environmental value.

SUMMARY

Manure water nutrients are potentially worth tens of thousands of dollars annually on typical dairies. On the larger dairies or with higher proportions of the manure captured in the flush system, this can amount to hundreds of thousands of dollars. Dairy farmers are very receptive to adopting techniques that would recover even a portion of this value, but they need to observe and test what works in the real world. Although each dairy seems to possess a unique set of infrastructure and personnel constraints, there is enough of a common experience that growers can learn from each other, as well as from data collected on their own dairy. The grower-to-grower process used in the BIFS project has been useful, as has the frequent two-way flow of information from producer to researcher and back.