A Survey of Dairy Manure Management Practices in California

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ABSTRACT

Written (n = 139) and oral (n = 45) surveys were conducted to identify practices for the collection, storage, and use of manure on California dairy farms in Tulare, Fresno, and Madera counties. The purpose of the survey was to develop benchmark data for development and implementation of research and educational programs to improve utilization of manure nutrients and to minimize adverse impacts to ground and surface waters. The 53.2% response rate represented 16.4% of the dairies in the three counties. Mean milking herd size ranged from 381 to 910 cows. Additional dry cows and replacement heifers were present. Producers used a combination of manure collection techniques (75.6%) or a single technique (24.4%). Data did not total 100% because multiple techniques were reported. Liquid wash or flush waters were stored in ponds on 95.9% of the dairies. Settling ponds or basins (39.1%) or mechanical solid separators (14.2%) were used to reduce the solid loading rate in storage ponds. Manure solids were collected by tractors (solid system) or from settling ponds or basins (liquid system). Few producers (4.1%) identified composting as a component of manure handling. Liquid manures were used for year-round irrigation (62.2%), spread as a slurry (9.5%), sold or transported off the farm (12.2%), or seasonally irrigated (62.2%). Solid manure was spread on farm land (78.4%), used for bedding (27.0%), sold off the farm (58.1%), removed from the farm (6.8%), or composted (5.4%). Sampling and nutrient analyses of soils and manure solids and liquids were seldom performed. Results from this survey indicate a need for the development of educational programs to improve the management of manure nutrients.

(**Key words**: manure collection, storage, utilization, management practices)

INTRODUCTION

The interaction of manure management practices with air and water quality has gained increased attention, and current practices must be assessed to develop research and educational programs that implement alternative management techniques. Passage of the Coastal Zone Act Reauthorization Amendments (5) and a publication of the Environmental Protection Agency (6) have prompted regulatory agencies in coastal states, those that border on oceans or the Great Lakes, to evaluate their nonpoint source pollution control program. Nonpoint source management measures (6) that are related to animal agriculture have been established to protect coastal natural resource areas. These measures have specified the collection of wash and run-off waters from facilities with as few as 28 dairy animals and the management of manure nutrients through a cropping system. The latter concept implies that soil analyses and application of manure nutrients to the land must be made at appropriate rates and at times that are defined by the nutrient requirements of the crops. The intent of the animal-related component of the legislation was to minimize the negative impacts of the application of manure nutrients to ground or surface waters.

Historically, federal regulations have addressed point sources of contamination (4). Concentrated animal feeding operations (1000 feedlot animals; 300 dairy animals with a stream flowing through the property and 700 dairy animals without a stream flowing through property) were defined as point sources (7) and were required to retain run-off and water containing manure on the property in an appropriate structure. The focus of early federal regulations was to prevent point source contamination of surface waters. States had the opportunity to make regulations that were more stringent than federal regulations. Remaining sources of contamination were nonpoint sources by definition. In California, the State Water Resources Control Board initially passed regulations that addressed both point and nonpoint sources of pollution that contaminated the quality of either ground or surface water (3). In fact, detailed regulations that are pertinent to manure storage ca-

Received July 25, 1996.
Accepted January 13, 1997.

TABLE 1. Response rate by county and characteristics of the dairies surveyed.

Parameter	County			Total or mean
	Tulare	Fresno	Madera	
Herds, no.	288	114	48	450
Herds surveyed, no.	90	35	14	139
Respondents, no.	44	22	8	74
Response rate, %	48.9	62.9	57.1	53.2
Lactating cows, no.	910	865	381	837
Dry cows, no.	155	144	64	142
Bred heifers, no.	245	247	51	253
Calves and open heifers, no.	445	538	117	604
Land available for manure application, acres	448	610	314	487

pacity and use have existed in California since 1984 (1). These regulations include the capacity to store rainfall that has been contaminated by manure (and maintain storage capacity for a 25-yr, 24-h storm event), the requirement for the storage structure to have the impermeability of a 10% clay soil, and the application of manure at proper rates to farm land.

Meadows and Butler (2) conducted a survey to identify dairy waste disposal practices. Those researchers surveyed four areas of California; the Southern Valley region surveyed in that study consisted of Fresno, Kings, Tulare, and Kern Counties. The survey instrument in that study was used to develop the current survey to allow the greatest comparison of results. Although some questions were similar, additional questions were used to identify potential components of nutrient management.

Staff at regulatory agencies have been unable to conduct market surveys to assess current practices and their potential to degrade water quality. Therefore, those agencies lack current information to identify which practices could be altered to maintain or improve water quality. Crop consultants do not consider manure nutrients when determining crop nutrient needs. The diverse agricultural environment of California prevents the staff of the Natural Resource Conservation Service and advisors from the University of California Cooperative Extension Service from making recommendations regarding farm nutrient management. The purpose of this survey was to collect benchmark information on current manure handling practices in the southern San Joaquin Valley of California. The information is necessary to develop and implement research and educational programs that encourage adoption of desirable techniques for managing manure nutrients.

MATERIALS AND METHODS

Three counties in the southern San Joaquin Valley were selected: Tulare (225,000 dairy cows), Fresno (85,000 dairy cows), and Madera (35,000 dairy cows). These counties constitute a growing dairy region. A complete list of producers (n = 450) was obtained from the California Department of Food and Agriculture. One hundred fifty producers were selected randomly to receive the survey. Eleven of these producers had relocated or no longer had a dairy enterprise. The remaining producers received a presurvey introductory letter indicating the purpose of the survey and the amount of time required to complete it. The survey packet arrived 7 to 10 d later and included a survey booklet; a preaddressed, stamped envelope; and a Real® seal lapel pin (participation award; California Milk Advisory Board, S. San Francisco, CA). The cover letter restated information found in the introductory letter and indicated that some respondents would be selected randomly for a brief telephone interview.

The survey booklet contained 20 questions (multiple choice and fill in the blank). Questions were unbiased and openended. When appropriate, the last choice was "other," which allowed producers the opportunity to identify an answer if it was not previously listed. Booklets were identified by number to minimize follow-up letters to remind individuals to return the survey. Logistical constraints required that a reduced sample size be interviewed orally. Individuals who returned surveys within 1 wk (n = 45) were contacted within 1 mo to schedule and respond to a 30-min telephone interview. Questions (n = 11) asked during the phone interview were more specific and required more detailed answers and opinions than did questions in the written survey.

RESULTS AND DISCUSSION

Written Survey

The response rate for each county ranged from 48.9 to 62.9%. Characteristics of the herds managed by the respondents are presented in Table 1 according to

county. The mean number of lactating and dry cows per acre that was available for manure application was 2.3 (Tulare), 1.8 (Fresno), and 1.3 (Madera). Additionally, the number of calves and heifers (open or bred) that was available per acre averaged 1.5 (Tulare), 1.4 (Fresno), and 0.8 (Madera). The rule of thumb used by the Regional Water Quality Control Board for dairy planning and permitting is application of manure from 3 to 5 cows per double-cropped acre. Customarily, in Tulare county, the rule of thumb is application of manure from 6 to 10 cows per double-cropped acre. This higher rate is based on the assumption that one-half of the solid manure is transported off the farm. The mean number of cows and the mean number of acres for manure application complied with the standard recommendation. However, 22 dairies had more than 5 cows per double-cropped acre. Eleven of these dairies had more than 80% of the solid manure transported off the farm, 8 had 20 to 80% of the solid manure transported off the farm, and 3 provided no information regarding the end disposition of solid manure.

Herd size has increased from 748 lactating and dry cows in the 1988 survey (2) to 979 cows presently. The numbers of bred heifers and calves and open heifers have increased from 168 to 253 and from 371 to 604, respectively. Farm acreage increased from 501 to 685 acres, and land available for manure application increased from 379 to 505 acres. Means across the three counties were used to express the data. Often, when existing herds increased in size, few or no adaptations were made to the manure management system.

Producers reported various techniques for the collection of liquid and solid manure from the corral, cow barn, and feed alley areas. Some producers provided more than one answer and, therefore, data do not total 100%. Producers were not questioned about cleaning the milking barn area. A combination of flushing and scraping was used by 64.9% of the producers. When only one method of manure collection was used, flushing (12.2%) or daily or periodic scraping (18.9%) were reported. An additional 4.1% of producers had more extensive combinations of manure collection that included manual cleaning. The percentage of producers using flush collection (77.1%) was greater than the 61.7% reported previously (2). Storage and utilization of liquid manure and holding pond effluent most likely require a greater capacity than that in previous years, although previous data were not available for comparison purposes.

Holding or storage ponds were present on 95.9% of the dairies: 4.1% had no ponds, 59.5% had one pond, 24.3% had two ponds, 8.1% had three ponds, and 4.1% had more than three ponds. Producers with no method on their property of holding wash water or run-off that had been contaminated by manure were violating state water law. The mean total storage capacity for liquids was 48.57 acre-ft (6.02 ha-m) of water storage capacity (2,115,724 ft^3; 59,886.8 m^3), which represents the available storage capacity, although there would remain 2 ft of free board from the surface of the pond to the top of the pond structure. There was a mean of 115,673 ft^2 (10,757 m^2) of pond surface area. Evaporation ponds were used for temporary storage and disposal (9.5%) of waste water and the removal of remaining solids. A pair of evaporation ponds was filled intermittently and then allowed to evaporate. After the first pond filled, water was diverted to a second pond while water in the first pond evaporated; the residual material was removed and handled as a solid.

The common belief that most large dairies utilize some type of mechanical solid liquid separation was disproved. On 54.1% of dairies surveyed, solids were separated from liquids by settling ponds or basins only (29.7%), mechanical solid liquid separators only (9.5%), or evaporation ponds only (5.4%). Additionally, some producers (9.5%) used a combination of techniques to remove solids; 39.1% of producers used settling ponds or basins; 14.9% used mechanical solid liquid separators; and 9.5% used evaporation ponds. Producers were not asked to indicate whether they had used mechanical separators previously (nonfunctional, obsolete, etc.). In retrospect, answers to this question might have explained why producers thought that more than 50% of dairies use mechanical solid liquid separators.

Manure utilization varied by source. Liquid manure and run-off that had accumulated in ponds was applied to the land through seasonal (29.7%) or year-round (33.8%) irrigation only or was utilized with more than one management technique. When more than one utilization technique was used, producers specified seasonal irrigation (32.5%), slurry spreading (9.5%), year-round irrigation (28.4%), or off-farm sales (12.2%). Producers most commonly (67.6%) responded that the primary reason to apply liquids to the land was to meet crop nutrient needs. However, 54.1% of producers indicated seasonal or year-round irrigation was performed to maintain the required 2 ft free board space in ponds.

Almost all producers included scraping solid manure into piles (94.6%) as part of their solid manure collection practices. Two producers did not answer this question, and 2 others sold manure off their

property. The latter individuals did not indicate whether tractor scraping and drying were used.

Producers indicated that solid manure was spread on the fields (28.4%), was sold (16.2%), or was used for bedding (1.4%) when only one method of utilization was recorded. Regardless of the number of solid manure management techniques used, solid manure was spread on the fields (78.4%), was sold (58.1%), was used for bedding (27.0%), was removed from the farm (6.8%), or was composted (5.4%). Some producers identified multiple methods of utilization; therefore, values do not total 100%. According to the survey, the primary reason (50%) for the removal of stored manure solids was to meet crop nutrient requirements. Disposal of solid manure was the sole response from 8.1% of the producers or was included in the response list from other producers (13.5%).

Solid or liquid manures were applied to farm land. Commonly reported crops that received manure applications included corn for silage, forage, cereal grains for silage, and cotton. One to 3 producers reported application of manure to sugar beets, grapes, olives, sudangrass, pasture, or tomatoes.

Producers were asked to indicate what percentage of their farm land was single, double, or triple cropped. Fourteen producers (18.9%) did not respond. Other producers reported that all farm land was single cropped (12.6%) or that all farm land was double cropped (27.0%). One individual reported a combination of single, double, and triple cropping. Fifteen producers (20.3%) single cropped 40 to 60% of their land, and the remainder was double cropped.

The written survey included a question to identify how producers determined crop nutrient needs. Of the 50 producers (67.6%) who indicated that solid or liquid manures were applied to meet crop nutrient needs, 7 (9.5%) did not identify how nutrient needs were determined. The remaining 43 producers identified experience (n = 20; 27.0%), annual soil testing (n = 4; 5.4%), periodic soil testing (n = 4; 5.4%), or other (n = 2; 2.7%). Producers indicated that experience and annual soil testing (n = 3; 4.1%) or experience and periodic soil testing (n = 10; 13.5%) were used to determine application of manure nutrients.

Phone Survey

Forty-five producers participated in a phone survey to quantify more precisely practices used to manage manure. Producers were asked to quantify the amount of time associated with cleaning corrals, barns, and feed lanes weekly. Categories were <14 h (57.8%), 15 to 29 h (22.2%), 30 to 59 h (15.6%), and >59 h (4.4%).

Although the written survey indicated that solid and liquid manures were applied to meet crop needs (62.2%), to reduce the pond level (18.9%), or to dispose of stacked manure (10.8%), the phone survey results indicated that 57.8% of producers applied manure because it was available; 11.1% of producers applied manure because it was available and because of soil test results; 20.0% of producers applied manure because of soil test results and experience; and 4.4% of producers cited only experience as the reason for applying manure.

Almost half (51.1%) of the producers did not test the soil. The remaining producers tested the soil every 3 yr (20.0%), 2 yr (11.1%), annually (15.6%), or more than once per year (2.2%). Some producers (26.7%) had previously obtained soil maps.

Results from the written survey indicated that manure nutrients were applied to meet crop nutrient needs (62.2%). Phone survey results indicated that 51.1% of producers did not test the soil, 91.1% did not test manure, and none estimated legume N fixation.

CONCLUSIONS

Results of the written survey indicated that few producers adequately considered the nutrient content of manure when it was applied to the land. Few individuals tested the soil on any regular basis. No producer reported testing the nutrient content of manure. There is a great need for local demonstration projects and educational activities to account appropriately for manure nutrients in standard cropping systems. The results from the written and oral surveys differed. When producers were given a choice of reasons for manure application to the land (written survey with multiple choice questions), they responded with a socially correct answer (manure applied to meet nutrient requirements of crops). There was no evidence that this actually occurred because of the lack of nutrient testing and because of the different answers to the phone survey. Producers applied manure to the land because it was available.

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