Manure Technical Bulletin Series
University of California Cooperative Extension

Applying Dairy Lagoon Water to Alfalfa

This bulletin discusses use of dairy lagoon water on alfalfa and summarizes a field experiment conducted on a Fresno County dairy farm.

Introduction

California dairy farmers apply lagoon water (liquid manure) to forage crops through gravity (border check and furrow) irrigation systems, but generally they do not apply it to alfalfa during the summer and may apply only moderate quantities to alfalfa during the remainder of the year. On some dairies, this limits the land area available for manure nutrient recycling and contributes to excessive applications on non-alfalfa cropland. Alfalfa, with its deep root system and perennial growth habit, is more effective in capturing nutrients than corn and cool-season annual grass forages like wheat and oats, and it has been shown in other parts of the US to limit transport of nitrate beyond the root zone to groundwater.

Because farmers usually do not apply nitrogen fertilizers to alfalfa, manure nitrogen does not have the potential economic value that it does when applied to corn and other non-legume crops; but manure P and K applied to alfalfa often has economic value by substituting for commercial fertilizers.

Farmers in California are reluctant to apply dairy lagoon water to alfalfa due to problems that have been observed, including the following:

1. Damage to alfalfa crowns due to scald (oxygen deprivation and high temperatures) when lagoon water is applied, particularly during hot weather
2. Accumulation of manure solids at the head of fields, which may smother alfalfa plants
3. Increasing weed growth
4. Increasing soil salinity

Experts in other U.S. states recommend avoiding manure application to alfalfa during the establishment phase (Lory et al. 2000[1]) Experience elsewhere also suggests that application of manure can harm alfalfa stands (Lory et al., 2000). However, most of the problems arise when manure application is applied at excessive rates or at inappropriate periods in the growing cycle. In California, damage to alfalfa from manure water tends to be greatest when manure water application cannot be carefully controlled and is thus applied at extremely high rates. Pre-plant manure applications to alfalfa in Minnesota supplied recommended crop nutrients and increased yield in the

[1] Lory et al. MU Extension. “Managing Manure on Alfalfa Hay”. Pub. G4555.

establishment year over the non-fertilized control (Schmitt et al. 1993[2]), but did not affect yield or N uptake after two years (Schmitt et al. 1994[3]). Application of dairy manure slurry on established alfalfa at rates equal to 100 and 300 lbs N/acre increased yield at one site in Massachusetts, but had no effect at another (Daliparthy et al. 1995[4]). Min et al. (1999a and 1999b[5]) found no detrimental effects on yield or stand persistence with dairy slurry application of up to 1700 kg total N ha^{-1} yr^{-1} to alfalfa-grass mixtures.

UC On-Farm Field Study in Fresno County, 1999-2002

We conducted a three-year trial on a dairy farm in Fresno County to determine whether properly managed dairy lagoon water could be used on alfalfa without causing the problems mentioned above or reducing alfalfa yield and forage quality. This research was part of a larger project focused on dairy manure nutrient management in the San Joaquin Valley (see BIFS project final report, Pettygrove et al. 2003, listed in references).

Methods and Dairy Lagoon Water Properties and Amounts Applied

The experiment was set up in the alfalfa fields of a participating dairy producer, with a different field chosen for each of three years (1999-2000, 2000-01, 2001-02). The field used each season was in its final year of production, reducing the potential risk, as perceived by the grower, of applying lagoon water to the crop. The experimental design was a randomized complete block, with three replicates. Plots were irrigation checks separated by borders, with plot sizes ranging from 2.7 to 4.2 acres (1.0 to 1.7 hectares) over the three years. Due to the long, narrow shape of the plots, all data were collected at two or three locations within each plot, allowing for further statistical separation of effects by location in the field.

The two treatments applied to plots were 1) without lagoon water and 2) lagoon water applied in late fall and/or early spring irrigations. The treatments were irrigated similarly so water was not a limiting factor. Manure water (lagoon water) was added to the fresh irrigation water at the storage lagoon using the dairy's typical manure application system. For year 1, manure volume flow was measured using a Doppler meter strapped onto the outside of the vertical pipe (flowing upwards). For years 2 and 3, an electromagnetic flow meter was installed by the farmer in the pipe to measure flow rates and total volume. Samples of the manure water were collected as it flowed through the pipeline near the flow meter. Samples were analyzed for total N, NH_4^+-N, P, K, pH, EC and total solids (Separate manure water samples were collected just before the irrigation and analyzed for ammonium N using Nessler's Reagent. In order to achieve an approximate rate of 50 lbs N/acre (56 kg N/ha), the target flow rate (to be set in gallons per minute) for the manure water was calculated using irrigation set times as expected by the farm personnel. A bypass valve was adjusted to return a portion of the manure water back to the pond until the flow rate as measured by the flow meter was near the target.

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[2] Schmitt et al. 1993, J. Prod. Agric. 6:385-390.
[3] Schmitt et al. 1994. J. Prod. Agric. 7:104-109.
[4] Daliparthy et al. 1995. J. Prod. Agric. 8:495-501.
[5] Min et al. 1999. Asian-Aust. J. Anim. Sci. 12:758-765 and 12:766-771.

Table 1). EC of the mixed water at the field valve was measured routinely to ensure that salinity was below threshold levels for alfalfa.

Separate manure water samples were collected just before the irrigation and analyzed for ammonium N using Nessler's Reagent. In order to achieve an approximate rate of 50 lbs N/acre (56 kg N/ha), the target flow rate (to be set in gallons per minute) for the manure water was calculated using irrigation set times as expected by the farm personnel. A bypass valve was adjusted to return a portion of the manure water back to the pond until the flow rate as measured by the flow meter was near the target.

Table 1. Characteristics of manure water applied to alfalfa field, prior to dilution with fresh irrigation water. Total N is Total Kjeldahl Nitrogen, nitrate concentration was negligible.

Date	Total N [6]	NH_4-N	P	K	pH	EC (umhos/ cm)	Total Solids (%)	EC of mixed water (umhos/cm)
	----------mg/L----------							
4/6/2000	255	220	26	220	---	---	---	---
5/6/2000	263	243	65	470	---	5090	---	1120
2/8/2001	220	211	89	457	7.1	4490	---	---
4/6/2001	38	27	14	45	6.9	1140	---	---
5/11/2001	115	97	33	123	---	---	---	---
10/16/2001	244	222	62	385	7.2	4650	---	1100
4/2/2002	83	55	25	139	7.3	2120	0.14	---
5/7/2002	214	194	71	352	7.2	4020	0.50	1300

Total nutrient application was calculated using the nutrient concentration, flow volume measured, the time of irrigation for each check and the size of the area irrigated (Table 2). Farm personnel collected much of the data throughout the course of the irrigation, including total time of each irrigation set and flow meter total volume readings at the beginning and end of each set. Total N application tended to be slightly below the target, but was within the range expected taking into variations in composition of the lagoon water and pumping rate. An exception was in April 2001 when the manure water storage pond had been diluted significantly by the dairy operator in order to clean out solid material. In this case, the manure water pump could not pump the water fast enough to deliver 56 kg N/ha to the field.

Table 2. Manure water nutrients applied to alfalfa as measured with flow meter.

Date	**N (kg/ha)**	**P (kg P_2O_5/ha)**	**K (kg K_2O/ha)**	**Temperature hi/lo (°C)[7]**
Year 1				

[6] For all the manure water characteristics, Total N, ammonium N, P and K are average of all samples from each irrigation as analyzed by UC DANR lab (4/6/00 and 5/6/00 the P and K are from a commercial analytical laboratory). pH, EC, and Total Solids are as measured by research project personnel.

[7] Temperature is from Five Points, nearest CIMIS station

4/6/2000	38	9	40	28 / 9
5/6/2000	56	32	121	28 / 9
Total (Year 1)	***94***	***41***	***161***	
Year 2				
2/8/2001	63	56	150	16 / 8
4/6/2001	13	11	18	17 / 11
5/11/2001	35	23	46	37 / 15
Total (Year 2)	***111***	***90***	***214***	
Year 3				
10/16/2001	46	27	87	32 / 13
4/2/2002	32	22	65	31 / 11
5/7/2002	64	48	126	27 / 9
Total (Year 3)	***142***	***97***	***278***	

Harvest samples for yield, nutrient uptake, and forage quality were collected within two days of the grower's field harvest. Harvest interval was between 26 and 36 days during the regular growing season and with delays typical of commercial alfalfa production due to equipment or personnel problems on the farm. Although a total of eight to nine harvests were taken from the field during the season, data for this study was collected only for those harvests directly before and after the manure water applications, and up to two additional harvests following the final manure application. Prior to each harvest, ground cover was assessed to determine differences in weed cover or bare ground between treatments. The alfalfa was harvested using a Carter harvester, with total harvested area approximately 10 m^2. Plant samples were clipped from the edges of this harvested plot to be used for calculating moisture content and for determination of nutrient content and quality. Samples were dried in a forced-draft oven at 55-60 °C, then ground and submitted to the analytical lab for analysis. Data were analyzed separately for each year using repeated measures ANOVA, with the individual harvests comprising the repeated measures.

Field Experiment Results

The application of manure water to alfalfa was expected by some producers to negatively affect yield and quality of the alfalfa. However, at the levels of application used in this experiment, the alfalfa performed equally well with and without manure water application. There were no significant differences in any measured parameters, including yield, nutrient (N, P, K) uptake, TDN (total digestible nitrogen), or weed population. It should also be noted that lagoon water was only applied during the cooler part of the growing season, in the fall and spring, rather than in the hot summer when greater damage could be done by biological oxygen demand of the manure water.

Also, the fields chosen were in their final year of production. Additional research is needed to determine whether manure water application at these rates and at these times of the year is also possible in younger alfalfa stands and could be carried out over the typical 3- to 4 years of an alfalfa stand.

Table 3. Alfalfa NPK harvest removals and manure nutrient application rates. N applied is dairy lagoon water ammonium plus 50% of organic N.

	Total N	P2O5	K2O
	--- lb/acre ---		
Applied as manure*	196	111	375
Harvest removal-+manure	503	106	453
Harvest removal - no manure	477	102	420
manure vs no manure	ns	ns	ns

Table 4. Salinity level of irrigation water with and without dairy lagoon water. Alfalfa salinity tolerance threshold is 1.3 dS m^{-1}.

	Electrical conductivity, dS m^{-1}	
Date	Undiluted lagoon water	Diluted with fresh as used for irrigation
May 00	4.1	1.1
Feb 01	4.5	0.9
Oct 01	4.9	1.1
Oct 01	4.6	1.1
May 02	4.0	1.3

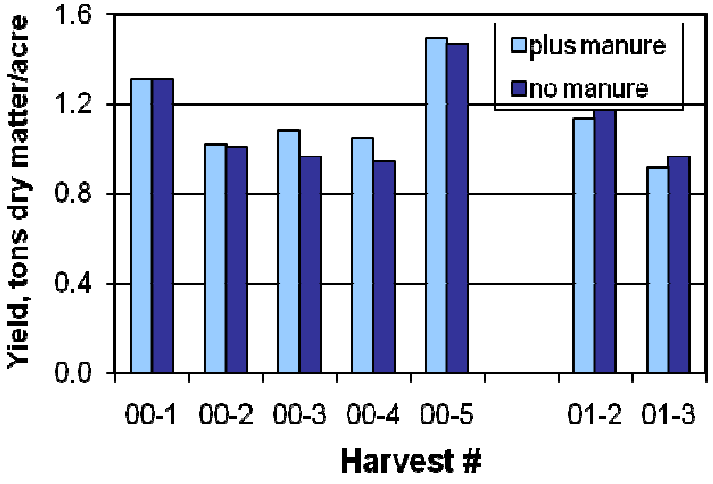

Fig. 1 Alfalfa yield as affected by manure (dairy lagoon water) application

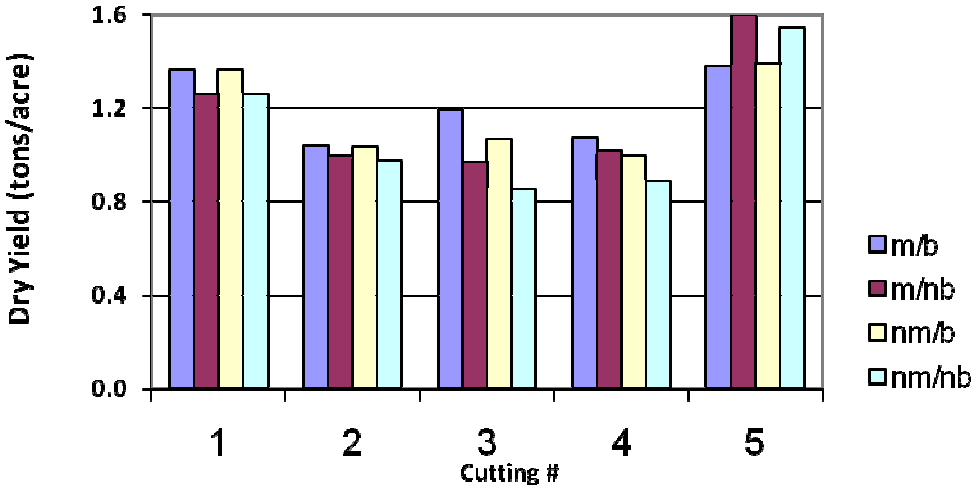

Fig. 2. Alfalfa yield as affected by berseem clover overseeding and dairy lagoon water application (m= manure, nm= no manure, b=berseem, nb= no berseem), 2000.

Conclusions and Discussion

The application of manure water (dairy lagoon water) to third and fourth year alfalfa in this study did not result in any differences in yield, forage quality, or weed pressure compared with the non-manured treatment. We conclude that dairy manure water can be applied at the tested rates and timing to alfalfa without negatively affecting the crop. Further research is needed to determine the long-term impacts of dairy manure water application to alfalfa. It is not known if a younger alfalfa crop (one to two years old) would respond differently to manure water applications, or if applications over a period of three to four years on the same crop stand would have a significant impact. Also, residual impacts of manure water application for the following alfalfa crop have not been measured. Long-term research could also determine soil quality and fertility impacts of this utilization of manure. In addition to this proposed research, it would be useful to farmers to know whether soil salinity (EC) thresholds published for alfalfa and based on typical ionic compositions of fresh water are appropriate for dairy lagoon water, which has more potassium and ammonium and less sodium.

Additional Information

Meyer, R.D., B.L. Sanden, and K.M. Bali. 2008. Lagoon water, manures, and biosolids applied to alfalfa. Publication 8306. Division of Agriculture and Natural Resources. University of California. Oakland, CA. http://anrcatalog.ucdavis.edu

Pettygrove, G.S. et al. 2003. Integrating forage production with dairy manure management in the San Joaquin Valley. Final Report. University of California Sustainable Agriculture Research and Education Program. http://www.sarep.ucdavis.edu/grants/reports/dairy/ (verified April 2010)

Pettygrove, S. and D.H. Putnam. 2009. Legume N credit for crops following alfalfa. University of California Cooperative Extension. Manure Technical Bulletin Series. Available at http://manuremanagement.ucdavis.edu (verified April 2010).

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