USING WINTER FORAGES FOR DAIRY NITROGEN MANAGEMENT

Marsha Campbell Mathews [1]

ABSTRACT

Winter forages play a key role in management of nitrogen on dairies because they can account for up to nearly half of the total nitrogen removal per acre. Proper application rates and timings of nitrogen are critical in order to avoid leaching of excess nitrogen to groundwater. Arial accumulation of nitrogen was monitored in multiple locations and years for several types of forages under a range of conditions. In most cases, the majority of the nitrogen is taken up during the months of February, March and April. Large amounts of nitrogen applied in the fall may be subject to leaching. To accommodate the uptake of nitrogen in the fall from lagoon drawdown, trials showed that it may be feasible to plant winter forages early in the fall and harvest a cutting before winter. Risks associated with this practice include difficulty with harvesting and severe losses from disease and/or lodging.

Key Words: manure, winter forage, nitrogen, lagoon, dairy, nutrient management

[1]UCCE Farm Advisor, Stanisluas County, 3800 Cornucopia Way, Suite A, Modesto, CA 95358; Email: mcmathews@ucdavis.edu. **In**: Proceedings, California Alfalfa and Forage Symposium, 17-19 December, 2003, Monterey, CA, UC Cooperative Extension, University of California, Davis 95616. (See http://alfalfa.ucdavis.edu).

INTRODUCTION

Misapplication of dairy nutrients to cropland has been found to account for about 80% of the elevated nitrate levels sometimes observed in shallow groundwater associated with dairies. For this reason, proper rates and timing of application of nutrients to cropland is key to protecting groundwater quality. In view of this, current and future regulations will probably require dairies in California to plan and monitor all nitrogen applications to their cropland. In most of California, the typical cropping pattern for dairy operations is to grow silage corn in the summer followed by a crop of small grain forage in the winter months. A common and successful practice for fertilizing corn has been to apply multiple split applications of commercial water-run nitrogen in irrigation water at rates and timings that match anticipated nitrogen needs. This same technique has been successfully demonstrated using dairy nutrient water applied at similar application rates and timings as commercial water run, by using a flow meter and control valve to apply targeted amounts of lagoon nitrogen to the corn crop. For winter forages, the proper timing and rates of application have been less clear even though winter crop nutrient uptake can account for up to almost of half of the total crop nitrogen uptake for the year.

TIMING WINTER FORAGE NITROGEN APPLICATIONS

To determine the time that winter forages take up nitrogen, replicated 2’x2’ or 3’x3’ forage samples were clipped from variety trials and grower fields over the course of the growing season and analyzed for dry matter accumulation and nitrogen content. Because some of the trials included sampling beyond the normal Northern San Joaquin Valley harvest time of mid-April or even sometimes late March, the maximum nitrogen uptake was based on the sampling closest to what would be a normal harvest date for that period. If samples were collected after that time, quite often they would show marked increases in nitrogen uptake as the crop matured and nitrogen removal rates would commonly exceed 200 lbs/acre. Forage wheat and triticale were especially apt to at times accumulate surprisingly large amounts of nitrogen late in the season, especially if nitrogen was applied late in the season when previous fertility had been marginal. Early oats such as Swan tended to take up nitrogen somewhat earlier than later maturing varieties. Nitrogen uptake patterns were not necessarily consistent, and responded to environmental factors such as the amount of nitrogen available in the soil. Generalized percent uptake of early-cut forage total nitrogen for the three winter months are given in Table 1. To use the table, determine the expected total nitrogen removal expected if the crop is cut for silage in early to mid April. An easy way to calculate final nitrogen uptake of silage is to multiply tons per acre of 70% moisture silage by the percent protein, then multiply by a conversion factor of .96 to get pounds of nitrogen removed. Multiply the total nitrogen uptake expected by the percent nitrogen uptake for the desired period. Example: A winter forage crop yields 15 tons per acre in mid April and has a protein content of 13%. 15 x 13 x .96 = 187 lbs N/acre removed. If this crop was planted on November 1, then, using Table 1, the crop would have taken up 30%, or 187 x .30 = 56 lbs of N/acre by the end of January.

Table 1. Generalized percent of total mid-April nitrogen uptake by planting date

planting period:	Mid-Oct	Early Nov	Late Nov/ Early Dec
% uptake by end of Dec.	30	20	10
% uptake by end of Jan.	40	30	20
% uptake by end of Feb.	55	60	30

As is evident in the nitrogen uptake table, at least 70% of the nitrogen uptake in winter forages takes place during late February, March and April. The rates of nitrogen uptake can be dramatic, with rates of as much as 100 lbs of nitrogen being taken up in a half-month period. This period of rapid uptake can be exploited to allow application of higher rates of nitrogen in a single water-run application of dairy nutrient water than could appropriately applied to a summer corn crop, where 40-60 lbs of N per acre is the usual target. Higher rates in a single application may be a useful option in situations where canal water is not available in the winter months to dilute the nutrient water and pump capacity is limited and pump capacity is limited. Avoiding overapplication in the winter months is further complicated by the tendency for nutrients in ponds be more concentrated in the winter than in the summer. Unfortunately, it is often difficult to avoid application rates that exceed the total expected crop requirement because reducing the flow rate of concentrated pond water can easily result in plugged pipelines. Strategies that may be used to decrease the application rate include:

- Properly sizing pumps and pipelines
- Providing excellent solids separation
- Diluting the pond with pump, district or roof water diverted into the pond
- Diluting the pond water with pump water as it leaves the pond and enters the pipeline
- Irrigating lighter soils when they are wet so that water will move across them faster
- Finding creative ways to obtain more dilution water, such as pumping into a blocked canal, then irrigating out of the canal

Avoiding winter applications of dairy nutrient water in an effort to avoid groundwater contamination is not as critical as once thought because the nitrogen in dairy nutrient water does not immediately leach to groundwater even if it is applied to wet soils. This is because the nitrogen in dairy nutrient water is either in the form of ammonium or is bound in particles of organic matter. Both of these forms of nitrogen tend to hang up in the top foot or so of soil, even if the soil is wet. The conversion from ammonium to nitrate is facilitated by bacteria. They convert ammonium (which resists leaching) to nitrate (which leaches readily) more slowly in cold soils than in warm ones. Another, more important safeguard is that the potential for leaching is lower during the spring months than during the summer irrigation season because only a very rare rainstorm could exceed the amount of water applied in a single typical irrigation. These factors, combined with the rapid uptake that typically occurs in the spring, provides some assurance that a single well-timed application of between 100 and 180 lbs N/acre, depending on expected crop uptake, can be applied with minimal negative impact on groundwater. If more nitrogen is needed, it should be split into two spring applications.

Table 2 presents soil and crop uptake data from a field with a loamy sand texture and a probable history of over-application of lagoon and/or commercial fertilizer nutrients. Soil sampling on 2/14/02 shows very little inorganic nitrogen available for crop uptake in the upper two feet of soil. Larger amounts of nitrogen in the third and fourth foot show that excess nitrogen had been applied in the past, and had moved past the roots before the crop grew large enough to utilize it. When the dairy nutrient water was applied, the nitrate in the fourth foot was likely leached, and the bulk of the applied ammonium remained in the top six inches. Using soil data, and correcting for nitrogen previously in the soil and taken up by the crop since the application, approximately 167 lbs of inorganic nitrogen was applied. During the seven weeks following application, 181 lbs/acre of nitrogen was taken up by the crop. The extra nitrogen likely came from mineralization of organic nitrogen. Six tenths of an inch of rain fell between 2/18 and 3/8, 0.22 inch between 3/8 and 3/21, and 0.66 inches between 3/21 and 4/4. The higher amounts of nitrate in the third and fourth foot in this example are due to historic overapplication. The loss of nitrate from the lower 2 feet would likely not have occurred if the field had not begun the winter with excess nitrate.

Table 2. Nitrogen in soil by depth and date (lbs N/acre) following lagoon irrig. on 2/14. Hickman, 2002

			2/14/02		2/18/02		3/8/02		3/21/02		4/4/02	
		soil depth	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N	NH_4-N	NO_3-N
summary lbs N/A		0 - 6"	3	4	114	11	10	49	7	38	6	28
soil top 2' on 2/18	183	6" - 12"	3	3	34	3	7	9	3	7	2	8
soil top 2' on 4/4	65	12" - 24"	8	8	16	5	10	14	2	14	3	17
difference	118	24" - 36"	4	18	11	16	14	35	3	21	3	18
used by crop	168	36" - 48"	5	46	8	16	7	5	3	26	3	24
Total inorganic N per acre in upper 2 ft of soil			30		183		98		71		65	
lbs N/A used by crop this period					13		94		47		27	

In order to obtain the most crop removal of nitrogen, it is essential to have good growth of the crop. In order for a winter forage crop to develop properly, it is important that the nitrogen application be timed to supply the nitrogen needs of the crop. One of the most critical periods for nitrogen to be available to winter forages is in the late winter and early spring, just before the period of rapid growth. However, soils are often wet during this period. If a crop is killed due to waterlogging as a result of a lagoon nutrient application, it will not be effective at taking up nitrogen. In heavier soils, one option is to put the crop on beds to provide internal drainage. It is also imperative that tailwater return systems be in place to prevent offsite movement of applied liquid manure water.

MAXIMIZING EARLY FALL NITROGEN UPTAKE

It is important for dairy operators to draw down their lagoons prior to the rainy winter months. Using the current management system, crop nitrogen uptake from planting to the end of January is only about 50 lbs N/acre, which in most cases is not high enough to accommodate the large amounts of nitrogen that need to be disposed of. Any excess application is subject to leaching if it is not utilized by the crop prior to the period of maximum uptake that occurs in spring.

There are at present two common options for forage crops that take up nitrogen in fall, between the time the corn silage crop is harvested and the traditional planting of winter cereal forage. The first is to triple crop sudan or sorghum-sudan, and the second is to plant the winter cereal in late summer/early fall and harvest a cutting before the rainy season begins.

Sudangrass thrives on heat, and grows poorly during cooler weather. On sandy soils, it is common to plant flat and irrigate up the sudangrass in order to save time, however there is some evidence that the faster growth rates achieved by planting to moisture can more than compensate for the extra time it takes to preirrigate. Sudangrass planted by mid-August can often make impressive tonnage and can remove up to about 200 lbs of nitrogen. In reality, however, because of the practicalities of getting the sudan planted in a timely way, and the uncertainties of fall weather, actual nitrogen removal may be far less than this, and many triple crop sudan crops fail to remove even 100 lbs/acre of nitrogen.

Sudan should not be planted after August, as the results will likely be disappointing. On the other hand, winter cereals should not be planted any earlier than mid-September, because they are adapted to cooler weather and tend to grow slowly when it is very warm. An unplanned comparison of Piper sudan and Kanota oat planted along side each other on August 25, 2002 (Sudan seed was leftover in the drill when planting oats) yielded 13.6 tons/acre @ 70% moisture (202 lb/A N removal) on October 21, compared to Kanota oat that yielded 2.9 T/A and removed 74 lbs/A of N. In the same year, a strip trial four kinds of winter forage was planted on September 12 in a field of Piper sudan. The winter forages and sudan were cut on November 5, and the field was planted to Dirkwin wheat following harvest. In this trial, most of the winter forages outperformed the sudan at the first cutting and final total yields and N removal showed no advantage to the triple crop sudan followed by forage wheat compared to an early planting of winter forage cut twice (table 1).

Table 3. 2003 Winter Forage Double Cut Strip Trial, Hilmar. Planted Sept. 12, 2002

	T/A @ 70% Nov 5	% protein	T/A @70% May 6	% protein	T/A @ 70% Total	lbs/A N removed Nov 5	lbs/A N removed May 6	Total lbs/A N removed
2700 Triticale	4.8 ab	22.1	21.2	10.8	26.0	102 a	227	329
Cayuse Oat	4.2 ab	21.1	21.1	12.3	25.3	86 a	256	342
Dirkwin Wheat	4.2 ab	22.0	16.3	11.3	20.5	89 a	174	263
Kanota Oat*	2.8 bc	22.3	21.9	11.1	24.7	61 b	233	294
Sudan/Dirkwin	3.3 c	13.9	13.7	14.3	17.0	44 b	188	233

*Kanota Oat initially had a very poor stand

There are significant risks associated with early planting, however. If weather prevents a fall harvest, tall forage can lodge, mat and rot following heavy rains and wind. If the winter is unusually warm, significant regrowth can occur even if a fall cutting occurred. Another problem associated with early planting is that several significant plant diseases can reach devastating populations if allowed to develop multiple generations on early planted forages, especially wheat. However, despite the risks, there are instances when triple cropping or early planting of winter forages are the only option for utilization of fall applied nitrogen.