MANAGING SILAGE FOR PROFIT AND ENVIRONMENTAL STEWARDSHIP

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Introduction

Forages (hay and silage) represent ~ 20-30% of input costs for the production of milk and therefore should be considered a valuable resource. This paper will attempt to highlight selected factors associated with forage management which are related to Profitability and Environmental Stewardship. Specifically we will cover: 1) Effect of silo type on recovery of corn silage, 2) Prevalence of mycotoxins in silages obtained from commercial dairies in Washington state, and 3) Nutrient management of grass silage for content of protein, nitrates, and nutritive value.

Silo Type and Recovery of Feedable Corn Silage

At this conference in 2001 I reported on a case study that we had conducted at the Werkhoven Dairy in Monroe, WA. The study involved the comparison of the recovery and feeding value of corn silage that was stored in a bunker vs the Ag Bag system. In January of 2002 we gathered the final data for calculation of feedable silage from the bunker silo. The dry matter fed as a % of that ensiled was 86.7 %, or 1099 tons of CS (DM basis) was recovered from 1268 tons of corn silage ensiled. The associated recovery of feedable DM from five Ag Bags was 98.5 %. The level of milk production that we reported last year when the two silages were fed to lactating cows was, bagged silage 114.4 lbs and bunker silage 113.7 pounds (not statistically different). In this particular case study the major advantage was in the recovery of feedable silage. We are continuing to gather data for recovery of feedable silage from the fall 2001 CS harvest and will report on that information as it becomes available.

Prevalence of Mycotoxins in Silages

Mycotoxins are toxins produced by molds, and can be found prior to ensiling or after ensiling of forages. Their presence in feeds has been related to poor reproductive performance, lowered milk production, decreased feed intake, increased SCC, and weight loss. A recent article in Hoard's Dairyman (Rankin, August 10, 2002 p. 517) suggests that mycotoxins maybe present in the field prior to harvest. While many have probably perceived this to be a problem of the Midwest, there is evidence to suggest their occurrence in silages in the NW is also likely. During this past year we had the opportunity to evaluate a set of 70 silage samples for the presence of mycotoxins. The samples we evaluated were collected from commercial dairies across WA state during an e-coli study conducted by the faculty of the Field Disease Investigative Unit in the Veterinary School and the Department of Animal Sciences at WSU during 1999-2001. Analytical testing of the samples was done by Dr Don Whitlow of North Carolina State. We focused on three

primary mycotoxins: Deoxynivalenol (DON) or Vomitoxin; T-2; and Zearalenone. Summarized in graphs 1 through 3 is the relationship of the level of each mycotoxin and silage pH. Any point that appears on the bottom axis indicates that it is below the level of detection. The average value presented in each graph represents mean value of those samples that had detectable levels of each mycotoxin. Levels of concern for each mycotoxin are suggested to be: DON, 300 to 500 ppb; T-2, 100ppb; and Zearalenone, 200-300 ppb. The results indicate that silage quality, as judged by silage pH, was not an indicator of whether a given mycotoxin might be present. The presence of T-2 was found in 12 of 70 samples, or 17% of the time; Zearalenone was found in 36 of 70 samples, or 51 % of the time; and, DON was found in 17 of 70 samples, or 24 % of the time. The sample set contained 30 samples of corn silage, 19 samples of grass silage, 13 samples of alfalfa silage, 7 samples of corn cannery waste, and 1 of earlage. Of the forages evaluated and shown to have detectable levels, corn silage seemed to be the most likely to contain one of the three mycotoxins (33% to 53% of samples with detectable levels were from corn silage). Grass silage, cannery waste, and alfalfa silage had detectable levels in 18 –31% of samples which were positive for one of the three mycotoxins. This field study would suggest that you should consider mycotxoins in your ensiled forages as a possible risk when trouble-shooting problems with lowered milk production, lowered feed intake, and decreased reproductive performance.

Nutrient Management of Grass Silage for Content of Protein, Nitrates, and Nutritive value.

Managing Nutrients for Grass Silage Production

Timely application and quantification of the amount of manure applied throughout the grass growing season can ensure that there is minimum leaching of nutrients into the ground water while improving the quality and quantity of grass harvested. During the 2001 growing season we conducted a precision nutrient management study at a commercial dairy to monitor the effects of manure and commercial fertilizer application on yields, grass nutritive value, and soil chemistry.

At each cutting we obtained clipping samples to estimate yield and nitrogen content. In addition, a sample of soil was collected at the time of harvest. Just after each cutting, samples of manure were analyzed for total N and NH4-N, and the total volume of manure applied was recorded. The accumulated amount of nitrogen harvested in the grass crop, nitrogen available from manure and commercial fertilizer, and estimated available nitrogen in the soil was totaled after each cutting and is shown in Figure 4. The results demonstrated that the amount of estimated nitrogen available to the crop and the nitrogen harvested were similar. In addition, soil nitrate levels remained similar over the last 4 cuttings.

Data collected from multiple fields during the 2001 growing season provided the dairy producer valuable information from which to make management decisions during the 2002 growing season. One important aspect to the 2001 study was the application of additional manure above his normal application rate after each cutting (increased from 1/2 to 1 inch per acre). Increased yields were observed by adding the additional manure earlier in the growing season (Figure 5). As a result, in 2002 the producer applied manure earlier in the growing season when the crop can use the manure for additional growth. Data collected in 2001 also helped him determine that his grass crop did not need additional commercial fertilizer.

If you would like to evaluate your crop-manure-soil relationship, consider collecting the following information:

1) 2ft x 2ft clipping of forage for yield and quality estimate
2) 1 ft soil sample at each cutting for nitrate
3) Manure sample (NH4-N and total N) and estimate of volume applied at each cutting

The forage sample will need to be sent to a commercial lab for analyses. The manure sample can be analyzed on-farm with simple equipment.

Managing Nutrients for Nitrate Levels in Grass

Nitrates accumulate when photosynthesis in the grass plant slows. Conditions when nitrate accumulations occur include:

(1) cloudy days (low levels of light)
(2) sudden drought during high summer temperatures
(3) sudden frost

Last year (2001) was ideal for nitrate accumulation in grass because there was less rainfall over the winter months. We think that less organic nitrogen was converted to volatile nitrogen and nitrates over the winter; therefore, there was the potential for nitrates to be higher the following summer. During the cloudy days of spring and early summer, photosynthesis in the grass plant is slower leading to the potential for nitrate accumulation.

During the summer of 2001, we had the opportunity to monitor CP and nitrate-N concentrations in fresh grass samples prior to each cutting in 5 fields at a dairy in Snohomish, WA. As the CP content increased in the grass, nitrate-N also increased (Figure 6). From a management standpoint, it is important to note that as the CP levels in grass increase above 17% there is potential for more nitrate accumulation in the grass plant.

Other observations from last year include:

(1) Nitrate-N levels in the grass tended to accumulate at every successive cutting through August (Figure 7).

(2) Nitrate-N levels were greater in the new seeding grass (planted in the spring) compared with old seeding grass. This may be due to:

    a. Increased mineralization (conversion of organic N to nitrate N) in the soil due to tilling the ground. Nitrate-N is the form of nitrogen that plants readily utilized.

b. Nitrate is not toxic to the plant, therefore, if there is more nitrate available in the soil, the plant has the potential to accumulate more (Bittman et al., 1999).

c. Commercial fertilizer was applied during planting. Applying high levels of fertilizer in the spring can increase the risk for nitrate accumulation in the plant during the first few cuttings.

There are a few management steps that can be used to feed forages high in nitrates:

(1) Ensile crop to reduce nitrate concentrations by 50%.
(2) Set chopper blades higher to leave more nitrate in the field (nitrates tend to accumulate in the stems).
(3) Change feeds gradually. Mix (dilute) high and low nitrate forages, and slowly increase the proportion of high nitrate forage fed to adapt the animals to high nitrate forages.
(4) Harvest in the afternoon on cloudy days when the amount of light is greatest (Bittman et al., 1999).
(5) Apply fertilizer or manure soon after harvest. Nitrate concentration in the plant is usually maximized approximately 2 weeks after application. Delayed fertilizer or manure application can lead to high nitrate levels at harvest (Bittman et al., 1999).

Last year the environmental conditions were present that allowed for nitrate accumulation in the plant. However, there are management practices that can be established to minimize nitrate accumulation in the grass crop. It is important to record the amount of manure and commercial fertilizer N being applied to the grass crop. This allows for timing of nitrogen application to minimize nitrate accumulation in the plant, and it can reduce the potential for over-application of nitrogen to the crop. It is also important to do fall soil nitrate testing to get an indication of the amount of nitrate that is present after the harvest season. This is another tool that can be used to monitor the under- or over-application of nitrogen to the crop.

Nutrient Profile of both Grass Silage and Diets containing Grass Silage of Differing Qualities

Three silages from a local dairy were collected and analyzed for various nutrients. The three samples consisted of grass silage from an established grass stand (planted in 2000 and 2001), grass silage from a new seeding (planted in spring 2002), and malfermented grass silage. The new seeding grass silage (27.1%) had a greater CP concentration than the established stand of grass silage (16.9%; Table 2). However, the other fractions of protein (soluble CP, ammonia, and ADICP) were similar between the new seeding and established grass stand (Table 2). Many times the high protein in the new seeding is an indication that there may be high nitrate concentrations in the forage, as was the case in this comparison (Table 2). Therefore, the new seeding should be analyzed for nitrates, and the nitrate concentration in the grass silage should be taken into account when balancing rations using this forage. Fiber and lignin concentrations were lower in the new seeding compared to the established stand of grass silage (Table 2). This is an indication the stem to leaf ratio was lower in the new seeding than in the established stand. It also appears that sugar levels (not measured) in the new seeding were greater than the established stand because the lactic acid concentration was greater in the new seeding grass silage (Table 2). Lactic acid producing bacteria consumed sugar in the forage to make lactic acid as an endproduct. Therefore, if there is more sugar present in the grass it provides more energy for the lactic acid producing bacteria.

The malfermented forage showed the classical signs of a forage that had undergone a clostridial fermentation. The DM content was below 30%, which provides an environment for clostridial bacteria to grow (Table 2). The ash content was also higher than the other grass silages, which indicates that there may have been some soil contamination in the forage when it was ensiled (Table 2). Clostridial bacteria can live in the soil, therefore the soil may have inoculated the forage with clostridial bacteria. The pH and ammonia, acetic acid, and butyric acid concentrations were high and the lactic acid concentration was low indicating a clostridial fermentation (Table 2).

Three scenarios were used to evaluate the forages in CPM ration evaluator.

1. The diet typically fed by the dairy was entered into CPM, and differences in dietary parameters were measured between the 3 grass silages (established seeding, new seeding, malfermented).
2. The optimization program in CPM was used to balance the diet containing the established stand of grass silage. The established stand of grass silage was replaced with the malfermented grass silage in the optimized diet, and the comparison was made between the optimized established grass stand diet and the diet that replaced the established grass stand with malfermented grass silage.
3. The optimization program in CPM was used to balance 3 different diets using the 3 different grass silages (established seeding, new seeding, and malfermented).

In the first scenario, where the three forages were entered into the CPM ration evaluator as part of a typical diet fed by the dairy, the grass silage represented 15% of the diet on a DM basis, and the forage to concentrate ratio was 39:61. Other forages included corn silage (~9% of diet DM) and alfalfa hay (~14.6% of diet DM). The major ingredients in the concentrate mix included flaked corn, beet pulp, corn distillers, soybean meal, whole cottonseed, and canola meal.

The CP concentration of the diet was 1.6 percentage units greater for the diet containing the new seeding grass silage compared to the diet containing the established stand of grass silage (Table 3). The greater CP concentration in the diet increased the metabolizable protein and the amount of peptides and ammonia present in the rumen (Table 3). In turn, the efficiency of using metabolizable protein for milk protein synthesis decreased (Table 3). Both diets contained excess protein, however, the diet containing the new seeding grass silage was in greater excess. Microbial protein production and efficiency of microbial protein production were slightly lower for the diet containing the new seeding also (Table 3). Only carbohydrates and products of carbohydrate fermentation provide energy at rates sufficient for growth of most ruminal bacteria (CPM help session). Therefore, the amount of protein derived from bacteria is primarily dependent on the amount and fermentability of feed carbohydrates (CPM help session). The lower microbial protein synthesis and efficiency may be due to the slightly lower fermentability of carbohydrates in the diet containing the new seeding compared to the established seeding (Table 3).

The diet containing the malfermented grass silage did not have a CPM profile that differed greatly from the diet containing the established stand of grass silage. Microbial CP yield was lower, but that was mainly due to lower fermentable carbohydrates (Table 3). Metabolizable protein allowable milk was also ~2 pounds different between rations (Table 3). However, if the malfermented grass silage was fed at 15% of the diet DM it would cause many problems with health and production in the dairy cow. Therefore, it demonstrates the importance of visual observation of the forages being fed. The clostridial grass silage became suspect by sight and smell. It was sent to a laboratory for a silage fermentation profile. The fermentation profile confirmed that this forage had underwent a clostridial fermentation.

In the second scenario, the diet containing the established stand of grass silage was optimized in CPM. The established stand of grass silage was then replaced with malfermented silage (no optimization), and differences between the diets were evaluated. In this scenario, the CP content of the diet containing the malfermented grass silage was 1.3 percentage units greater than the diet containing the established stand of grass silage. The predicted MUN increased from 18 to 21 mg % when the grass silage in the diets switched from an established stand to malfermented, and the urea cost to excrete the excess nitrogen in the urine increased from 0.449 to 1.309 Mcal/day.

In the third scenario, three diets were optimized for each of the three grass silages. When CPM optimized the three diets, all of the nutrient constraints within the optimization program were met. Therefore, the 3 diets tended to have similar nutrient profiles and microbial protein production. The biggest difference between the three diets was the forage to concentrate ratio. The diet containing the malfermented grass silage had to feed a higher level of concentrate (F:C = 40:60) compared to the other diets (53:47). This suggests that more concentrate had to be fed to compensate for the poor quality forage.

Overall, the amount and type of protein present in grass silage will affect protein balance and excretion in the dairy cow. It is important to be aware of the amount of CP as well as the amount of soluble CP, ammonia-N, and nitrate-N present in the grass silage when balancing a ration. Overfeeding protein will lead to excess N being excreted in the urine. This not only has negative environmental implications, it also comes at an energy cost to the animal. When soluble N and ammonia-N are overfed there is less efficient use of metabolizable protein for milk synthesis, and when nitrate-N is overfed it can be a health risk for the animal.

Citations

Rankin, M. 2002. Mycotoxins start in the field...not the silo. Hoard's Dairyman. August, p.517.

Bittman, S., O. Schmidt, and T. N. Cramer. 1999. Advanced forage management. Pacific Field Corn Association, Agassiz, BC.

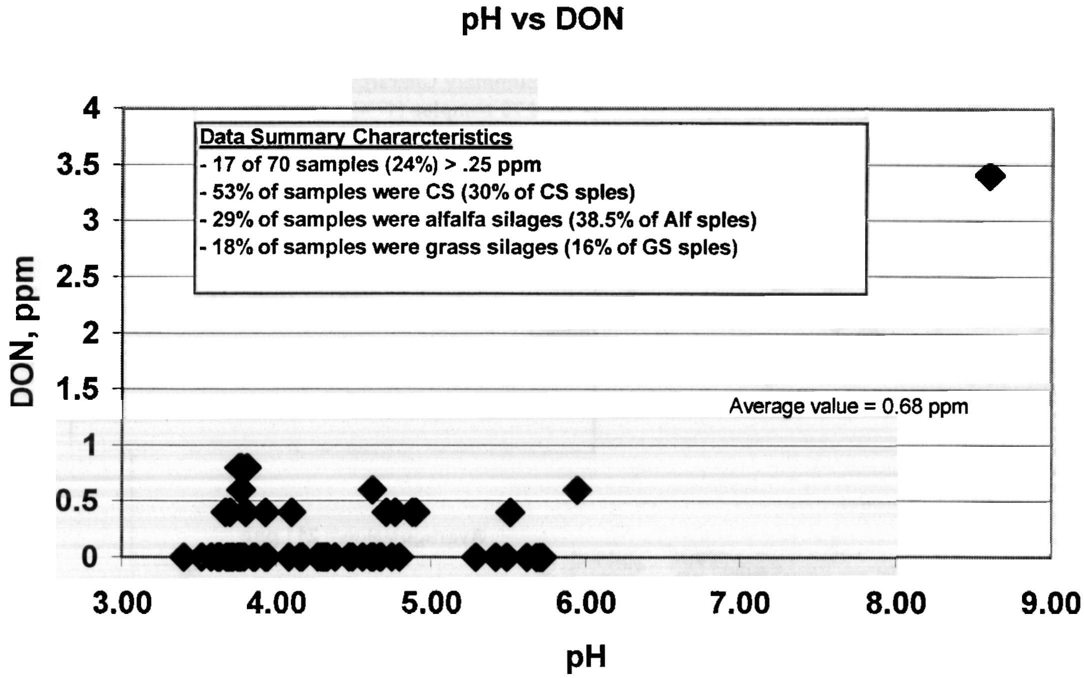


Figure 1 – Silage pH vs content of DON .

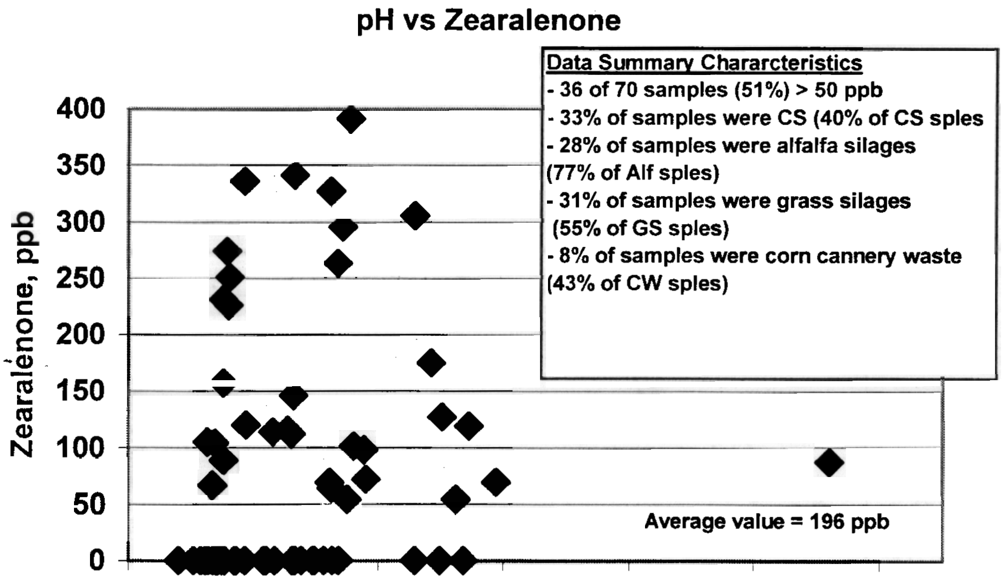


Figure 2 – Silage pH vs content of Zearalenone

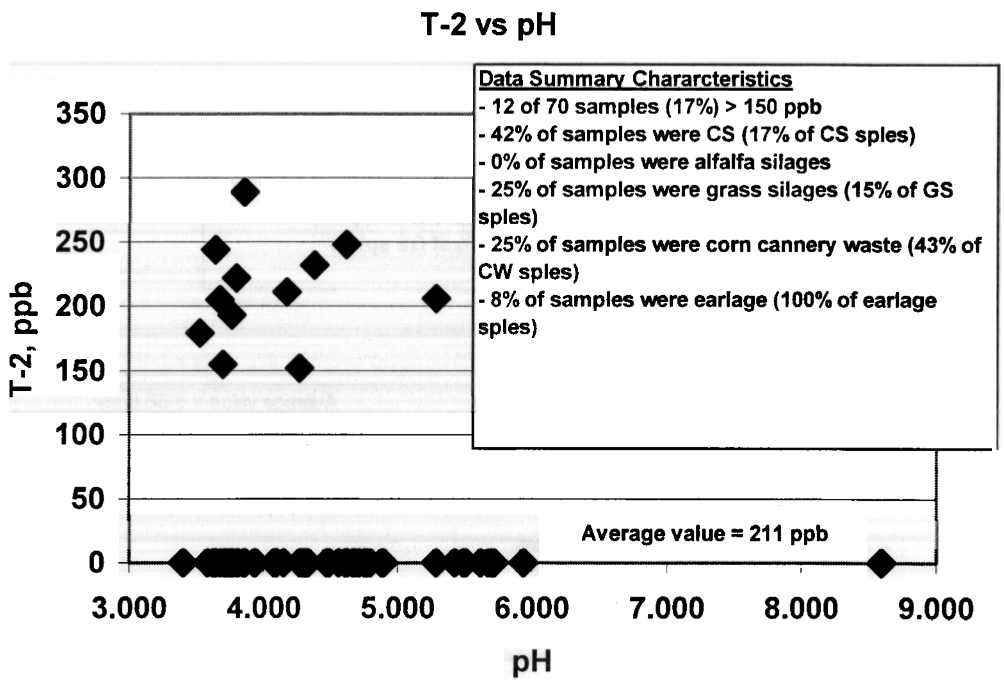


Figure 3 – Silage pH vs content of T-2 Toxin

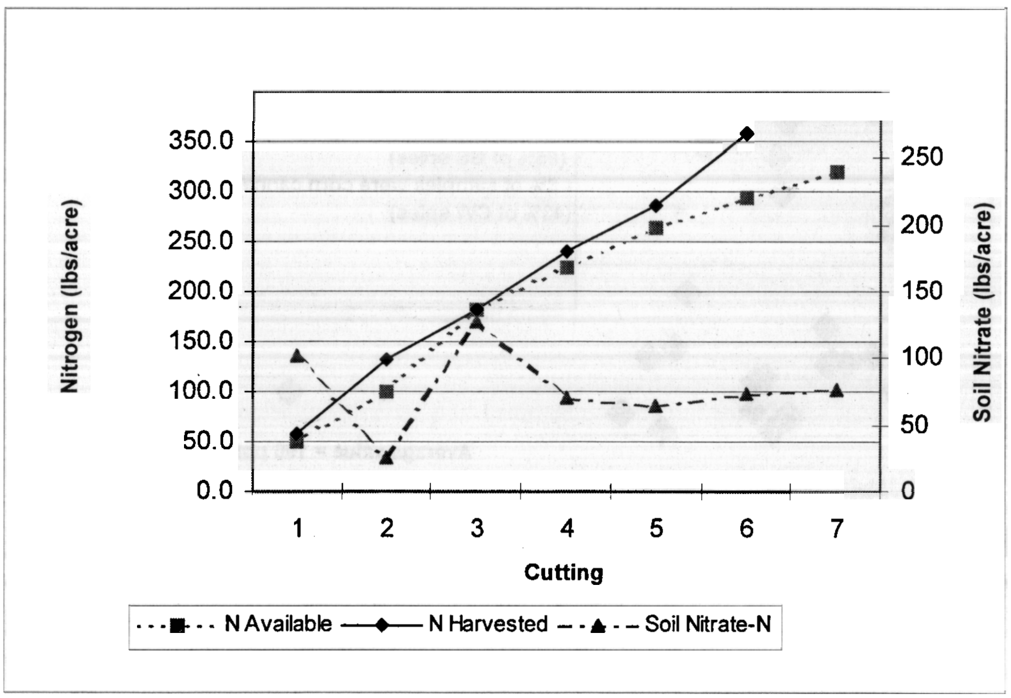


Figure 5. Accumulative DM Yield of Grass Receiving Different Amounts of Manure

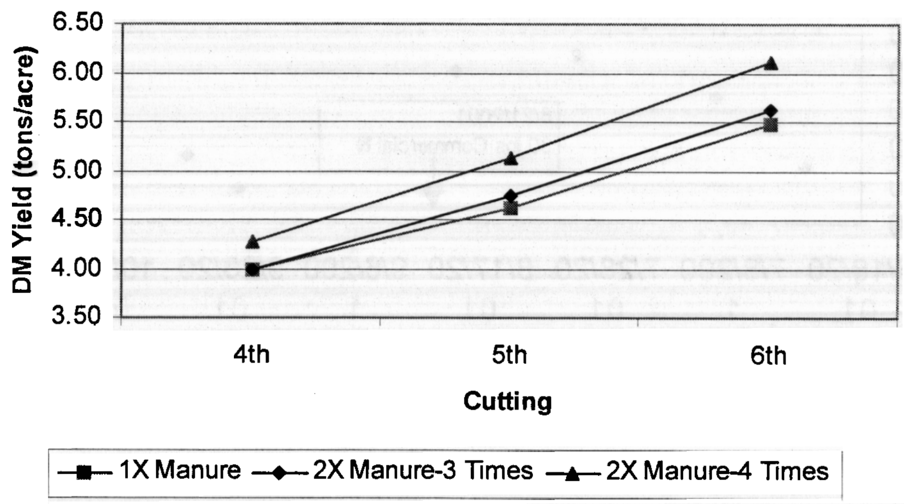


Figure 6. CP Concentration vs Nitrate Levels in Grass Silage

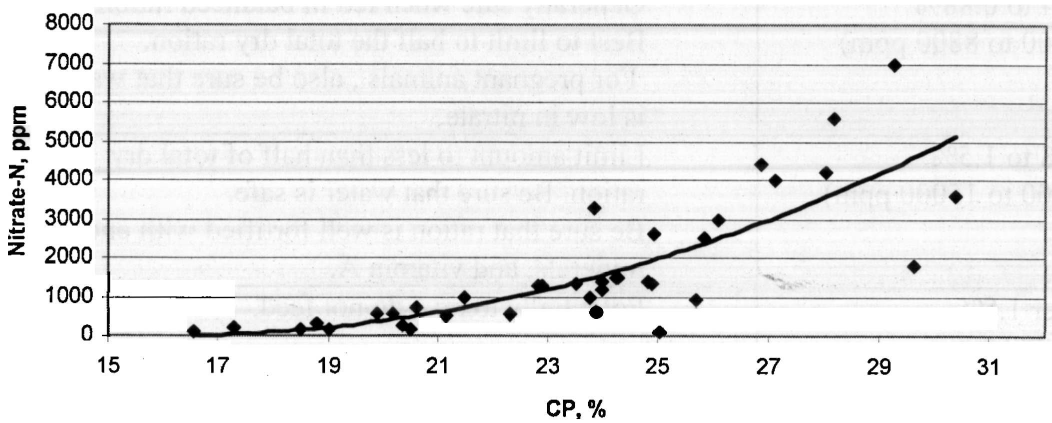
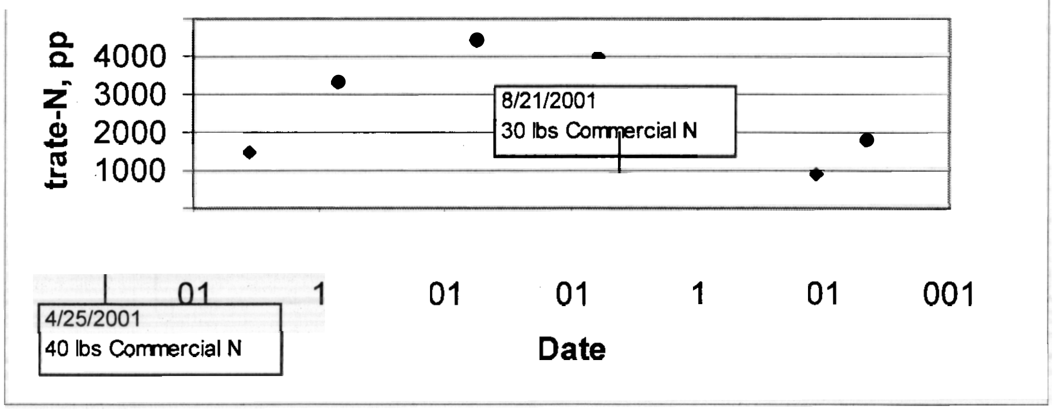


Figure 7. Nitrate-N vs Time



% NO3 on 100% DM Basis	Comment
Less than 0.44% (4400 ppm)	Safe
0.44 to 0.88% (4400 to 8800 ppm)	Generally safe when fed in balanced rations. Best to limit to half the total dry ration. For pregnant animals , also be sure that water is low in nitrate.
0.88 to 1.5% (8800 to 15000 ppm)	Limit amount to less than half of total dry ration. Be sure that water is safe. Be sure that ration is well fortified with energy, minerals, and vitamin A.
Over 1.5% (15000 ppm)	Potentially toxic – do not feed.

Original Source–Hoards's Dairyman August 25, 1970.

Some laboratories report nitrate analysis as per cent or PPM (parts per million) of KNO^3 or NO^3-N.

To use the above explanation tables, multiple % or PPM of KNO^3 by 0.61, or the % or PPM of NO^3-N by 4.4 to get the comparable % or PPM of NO^3.

If you receive analysis results stated as %, convert % to PPM by moving the decimal point four places to the right. To convert PPM to %, move the decimal four places to the left.

Table 2. Nutrient Profile of Grass Silage.

Item	Established Stand Grass Silage	New Seeding Grass Silage	Malfermented Grass Silage
DM, %	37.9	35.3	23.3
CP, %	16.9	27.1	22.8
Soluble Protein, % of CP	65.7	67.0	58.0
Ammonia, % of CP	5.1	6.7	66.8
Nitrate Ion, % of DM	0.38	0.98	0.44
ADICP, % of DM	1.8	1.9	1.4
NDICP, % of DM	2.4	3.3	2.8
NDF, % of DM	42.2	37.1	42.2
ADF, % of DM	28.2	23.6	29.1
Lignin, % of DM	4.7	1.0	2.9
Crude Fat, % of DM	4.7	5.9	6.8
Ash, % of DM	8.5	9.7	15.4
pH	4.3	4.2	8.3
Titratable Acidity, meq/gm	4.25	7.4	. . .
Lactic Acid, % of DM	7.3	9.5	0.8
Acetic Acid, % of DM	0.84	0.93	3.5
Butyric Acid, % of DM	<0.01	0.03	5.7
Total VFA, % of DM	8.1	10.5	10.7
Lactic acid/VFA	89.7	90.8	7.5

Table 3. Scenario 1 - Results using the CPM ration balancing program.

Item	Established Stand Grass Silage	New Seeding Grass Silage	Malfermented Grass Silage
DMI, kg/d	25.7	25.7	25.7
CP, % of DM	19.0	20.6	19.9
NDF, % of DM	28.8	28.0	28.8
NFC, % of DM	40.3	39.4	38.2
Metabolizable protein balance, g	213.3	253.9	172.6
Metabolizable protein allowable milk	118.7	120.7	116.6
Efficiency of MP for milk protein synthesis, %	59.2	58.2	60.2
Peptides in rumen, % of required	157	182	145
Ammonia in rumen, % of required	165	211	198
MP from bacteria, g/d	1560	1505	1495
Predicted MUN, mg %	19	22	21
Urea cost, Mcal/d	0.947	1.863	1.528
Microbial CP yield, g/d	2600	2508	2491
Microbial efficiency, g bact N/kg ferment carbohydrate	38.0	37.6	38.0
Fermentable carbohydrate, % of DM	42.7	41.7	40.9

Table 4. Scenario 2 - Results using the CPM ration balancing program.

Item	Established Stand Grass Silage	Malfermented Grass Silage
	(% of diet DM)	
Established grass silage	12.4	12.4
Corn silage	8.3	8.3
Alfalfa hay	9.4	9.4
Corn grain, flaked	12.3	12.3
Beet pulp	2.0	2.0
Corn distillers	5.0	5.0
Soybean meal	4.7	4.7
Other	2.4	2.4
DMI, kg/d	25.7	25.7
CP, % of DM	18.2	19.5
NDF, % of DM	31.2	31.2
NFC, % of DM	40.0	36.8
Metabolizable protein balance, g	92.1	49.2
Metabolizable protein allowable milk	112.6	110.5
Efficiency of MP for milk protein synthesis, %	62.3	63.6
Peptides in rumen, % of required	146	126
Ammonia in rumen, % of required	150	193
MP from bacteria, g/d	1575	1483
Predicted MUN, mg %	18	21
Urea cost, Mcal/d	0.449	1.309
Microbial CP yield, g/d	2624	2472
Microbial efficiency, g bact N/kg ferment carbohydrate	37.8	37.9
Fermentable carbohydrate, % of DM	43.3	40.7

Table 5. Scenario 3 - Results using the CPM ration balancing program.

Item	Established Stand Grass Silage	New Seeding Grass Silage	Malfermented Grass Silage
	(% of diet DM)		
Established grass silage	12.4	12.0	11.7
Corn silage	8.3	14.1	6.0
Alfalfa hay	9.4	4.2	4.9
Corn grain, flaked	12.3	13.7	19.3
Beet pulp	2.0	2.0	1.8
Corn distillers	5.0	5.0	3.5
Soybean meal	4.7	2.3	1.2
Whole cottonseed	...	0.2	6.4
Canola meal	...	1.0	0.8
Other	2.4	0.9	0.9
DMI, kg/d	25.7	25.7	25.7
CP, % of DM	18.2	18.1	17.5
NDF, % of DM	31.2	32.1	31.5
NFC, % of DM	40.0	40.0	40.0
Forage:Concentrate	53:47	54:46	40:60
Metabolizable protein balance, g	92.1	57.4	5.0
Metabolizable protein allowable milk	112.6	110.9	108.3
Efficiency of MP for milk protein synthesis, %	62.3	63.3	64.8
Peptides in rumen, % of required	146	150	115
Ammonia in rumen, % of required	150	147	145
MP from bacteria, g/d	1575	1613	1595
Predicted MUN, mg %	18	17	16
Urea costs, Mcal/d	0.449	0.401	0.208
Microbial CP yield, g/d	2624	2689	2658
Microbial efficiency, g bact N/kg ferment carbohydrate	37.8	37.7	37.9
Fermentable carbohydrate, % of DM	43.3	44.5	43.9