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Factors Affecting Nitrogen Losses as Measured Using Forced-Air Wind Tunnels and Nitrogen Mass Balance

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Summary

Two experiments using wind tunnels were conducted in conjunction with a N mass balance to evaluate the effect of clinoptilolite zeolite clay on ammonia (NH_3) losses. Ammonia losses were measured using the wind tunnels during the last six weeks of each feeding period and compared to losses calculated using a N mass balance. Nitrogen loss, pH, surface DM and N contents, and soil and surface temperatures were assessed as possible contributing factors. There were no differences in NH_3 volatilization due to dietary treatments. N loss was influenced by date, % DM, surface N and soil temperature. As measured by the wind tunnels, 26.4 to 29.2% of the total N loss (by mass balance) was lost as volatilized NH_3. The wind tunnel is a useful tool for measuring gaseous emissions; however, the short measurement period and small area of measurement may reduce the cumulative accuracy compared to mass balance techniques.

Introduction

Ammonia emissions are an environmental challenge facing livestock producers. There is a potential for feedlots to become regulated in regards to NH_3 emissions and nitrogen volatilization. One concern is how these emissions are measured and calculated, and whether the results are accurate.

Research at Nebraska has been conducted by measuring N loss using the mass balance method. This method takes into account the N consumed and excreted by the cattle. The N excreted is further measured as manure, soil, and runoff N. However, the mass balance method determines volatile N losses indirectly (by difference). N losses from the feedlot pen surface to the atmosphere are thought to be released predominantly as NH_3, and the wind tunnel can be used to measure NH_3 emissions directly.

The first hypothesis of this research is the wind tunnel will enable users to measure the N volatilized as NH_3, and that measured losses will be similar to N losses calculated using the mass balance technique. The second hypothesis is factors such as: DM, pH, soil temperature, and surface N, will affect the level of NH_3 volatilized.

Procedure

Two experiments were conducted on the effects of feeding clinoptilolite zeolite clay on N losses. These results are presented separately (*2006 Nebraska Beef Report,* pp. 90-91). Wind tunnels were used to sample NH_3 released from pens the last six weeks of each feeding period (March 25-April 29 and July 23-August 27). A wind tunnel was temporarily placed on the lot surface within each pen, and air was directed over the feedlot surface at 0.3 m/s for 30 minutes per pen. Collection was from 0900 to 1400 each day with pen order remaining constant throughout both experiments. A fraction of the airflow was diverted for analysis and NH_3 in this air was collected using a 0.2 *M* sulfuric acid trap. The tunnels were placed in similar locations within each pen (13 ft from the division fence and 24 ft from the concrete apron). The location was determined by a small preliminary study by Ryan Duysen in 2003. Pens were divided into six sections according to surface uniformity. Emission samples were collected and a weighted average was used to calculate the representative location for measuring NH_3. One-inch core samples were taken at four locations around the edge of the wind tunnel during each measurement period. The cores were composited and analyzed for pH, DM, and N. Surface and soil temperatures were taken at the start of each 30-minute run. Each vial of sulfuric acid solution was analyzed for NH_3 with a Seal AQ2 autoanalyzer. The NH_3 was then converted to g/head for each treatment (Table 1), accounting for the airflow rate of the wind tunnels, the tunnel and pen areas, and the stocking rate. These NH_3 levels were then incorporated into the N mass balance as lb/steer over the entire feeding period.

Results

Feeding clinoptilolite zeolite clay had no effect on cattle performance or N losses as no significant differences between the two treatments were present in either experiment (Table 1). Much more NH_3 was released during the summer experiment due to an increase in soil temperature and N level, which is in agreement with previous research. Using the mass balance technique, 28.7 and 29.5 lb of volatilized NH_3 - N per head were lost in the study conducted in the winter for cattle fed a control diet and zeolite treatment, respectively. In comparison, the NH_3-N losses, as measured using the wind tunnels were 7.7 lb and 13.4 lb of N per head. The estimated ammonia N loss using the wind tunnels was much lower than that calculated indirectly using mass balance measurements, averaging 35.1% of total excreted N compared to 40% based upon mass balance measurements.

Using the mass balance technique for summer fed cattle, 53.8 and 53.6 lb per head of NH_3-N were lost using the mass balance technique for control and zeolite treatments, respectively. Using the wind tunnels, 14.2 and 15.7 lb of NH_3-N were lost. As a percentage

Table 1. Nitrogen mass balance and ammonia emissions (measured using wind tunnels) during two separate feeding trials (expressed as lb/steer over entire feeding period).

Trial	Control	Clay	SEM	P-value
Exp 1				
Manure	43.9	42.8	2.4	0.64
Runoff	0.51	0.97	0.15	0.06
N lost[a]	20.9	16.1	4.0	0.88
N lost[b]	7.7	13.4	10.8	0.35
Exp 2				
Manure	12.0	11.1	0.9	0.55
Runoff	0.06	0.10	0.01	0.10
N lost[a]	39.6	37.9	0.9	0.90
N lost[b]	14.2	15.7	8.9	0.67

[a]N lost measured by nitrogen mass balance differences.
[b]N lost measured by wind tunnels as NH_3.

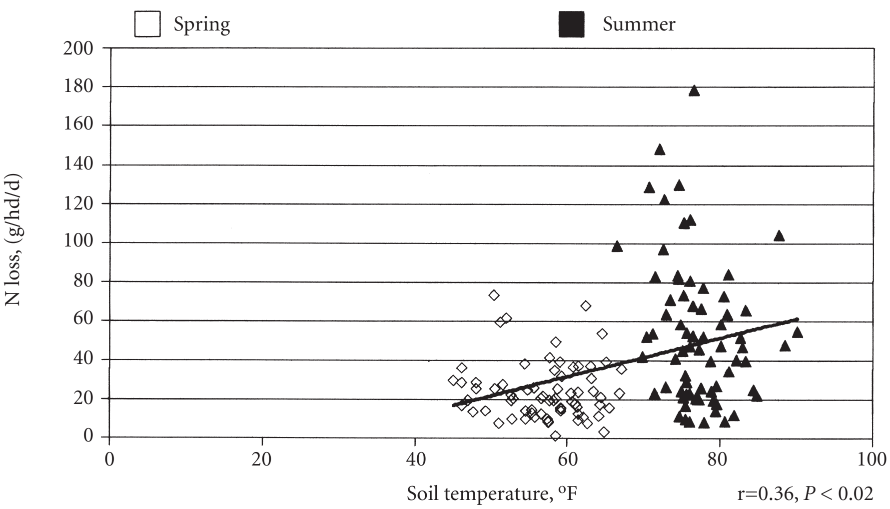

Figure 1. Correlation between N loss and soil temperature (all points of measure are combined).

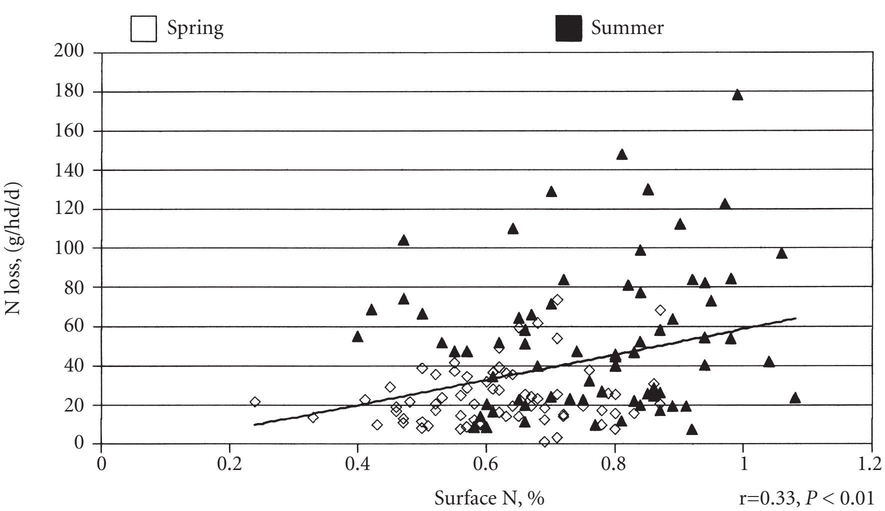

Figure 2. Correlation between N loss and percentage surface N (all points of measure are combined).

of total excreted N the wind tunnel measured N loss as NH_3-N as 26.4 to 29.2% for control and zeolite treatments, respectively, compared to 81.7 and 82.7 % based upon mass balance numbers. Therefore, either the NH_3-N losses are overestimated by the mass balance technique or the wind tunnel does not account well for total losses over 120 or 168 days.

The relationships of DM, pH, surface N and temperature to NH_3 loss, measured by the wind tunnels, were analyzed. In the spring period, N loss averaged 28.6 g/steer daily with pen surface samples averaging 3.85% N, 74.7% DM and 67.1°F. In the summer sampling period, N loss averaged 56.5 g/steer daily with pen surface averaging 4.8% N, 78.6% DM and 77°F. There were significant, but relatively weak correlations between N loss and soil temperature r = 0.36, $P < 0.02$) (Figure 1) and N concentration of the pen surface material r = 0.33, $P < 0.01$) (Figure 2). No correlation was observed between N loss and pH.

When the data were analyzed using a regression model, there was a significant effect of date on N loss, soil pH, soil N and DM contents, and surface and soil temperatures ($P < 0.01$). This is expected as time of year influences the temperature and moisture content of the feedlot surface.

With the use of the wind tunnels, researchers can measure NH_3 loss directly from open feedlot pens. However, a challenge with the use of the wind tunnel to quantify NH_3 losses is length of the measurement period and area measured. For example, during the winter trial in our study the wind tunnel measured 3 hours of emissions total per pen. The cattle were occupying the pens for a total of 4,032 hours; therefore, the wind tunnel only measured 0.07% of the time the cattle were in the pens. Additionally, the wind tunnel measures an area of 3.4 ft^2 in a pen with an area of 2,550 ft^2; therefore, the wind tunnel only measured 0.14% of the pen surface area. The wind tunnel is a useful tool for measuring relative differences between adjacent pens, presumably. More measurement periods may be needed to obtain a complete and accurate depiction of the NH_3 released from the pen surface over an entire feeding period.

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