

# NITROGEN MINERALIZATION FROM DAIRY MANURE AND ASSOCIATED COASTAL BERMUDAGRASS NITROGEN UPTAKE

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## Summary

Results of biologically-based soil tests were compared with N uptake from Coastal bermudagrass overseeded with wheat and Coastal bermudagrass only at Stephenville, Texas, in 1995. The sole N input was dairy cattle manure applied at 0, 100, 200, and 400 lbs N / acre. Strong correlations were observed between forage N uptake and soil microbial biomass N ( $r^2=0.92$ ), as well as a newly applied C mineralization (one-day CO<sub>2</sub> evolution) procedure ( $r^2=0.93$ ). Because of its simplicity and precision, measuring CO<sub>2</sub> evolved on the first day after the rewetting of dried soil is recommended for rapid estimation of potential N mineralization from surface-applied dairy cattle manure.

## Introduction

Dairy manure can supply Coastal bermudagrass [*Cynodon dactylon* (L.) Pers] with N, P, K, and other nutrients, but may potentially contaminate surface and groundwater when application is excessive. Nitrogen is released, or mineralized, as a consequence of the energetic respiration of carbon-containing compounds by soil microorganisms. The rate of N mineralization is dependent on factors influencing microbial activity, including soil temperature, moisture, pH, quality of the substrate, management practices and other soil properties. It is frequently difficult to accurately estimate the quantity of N which will be mineralized from manure, especially in soils which have previously received manure. A rapid and reliable soil testing method is needed to estimate N mineralization from surface-applied dairy cattle manure so excessive application of manure N and potential water contamination might be prevented.

Soil microorganisms are the agents of N mineralization, thus biological tests which characterize the quantity and activity of soil microbes might serve as the basis for a rapid N mineralization soil test procedure. Nitrogen is mineralized as a consequence of C mineralization which results in the production of CO<sub>2</sub>. Microbial cell requirements dictate that approximately 10 units of C are mineralized for each 1 unit of N.

Carbon dioxide released from C mineralization is often more easily quantified than

mineralized N. Thus, it might be feasible where N immobilization is not occurring to quantify CO<sub>2</sub> or some other microbially related characteristic as an estimator of N mineralization. The specific objectives of this study were to (1) relate soil microbial biomass N to longer-term lab estimates of soil N mineralization and Coastal bermudagrass N uptake in the field and (2) correlate a newly applied C mineralization (one-day CO<sub>2</sub>) test with the above parameters.

### Procedure

Soil samples were collected 8 times in 1995 from a study established in 1992 on a Windthorst fine sandy loam (fine, mixed, thermic Udic Paleustalfs) near Stephenville, Texas. This study has four rates of dairy manure N (0, 100, 200, and 400 lbs/ac/year) split in four equal applications during the year. Forage treatments consist of Coastal bermudagrass only and Coastal bermudagrass overseeded with wheat [Triticum aestivum L.]. Manure N rate and forage treatments are factorially combined in a randomized block with four replications. Each experimental plot is 10x20 ft.

Manure applications were made on 20 February, 20 April, 2 June, and 10 October, 1995. Soil samples were taken on 17 February, 10 March, 10 April, 20 May, 14 June, 21 July, 25 August, and 22 September, 1995. Thirty subsamples per plot were taken to a 3 in. depth with a 1 in. diameter coring device and composited.

Soil samples were returned to the lab, passed through a 5-mm sieve without grinding, and dried for 24 hours in a forced-draft oven at 104° F. Four 40-g subsamples from each plot were placed in plastic vials, wetted to 60 % field capacity with deionized water, and placed into a 1-qt canning jar. Each canning jar also contained a vial of 0.34 fl oz. (10 ml) of 1 M KOH and a vial of deionized water to maintain humidity (Franzluebbers et al., 1994). Jars were sealed and placed in an incubator at 77° F. At 7, 17, and 24 days after beginning the incubation, the vial of KOH was removed and replaced with a fresh vial of KOH to trap CO<sub>2</sub>. The KOH was titrated with standardized 1 M HCl to determine the quantity of CO<sub>2</sub>-C respired (Anderson, 1982). At each of the above incubation periods, a vial of soil was removed, dried at 131° F to stop mineralization, ground to pass a 2-mm sieve, and extracted with 2 M KCl for inorganic N determination. Mineralized NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup> were determined from filtered extracts using an autoanalyzer (Technicon Industrial Systems, 1977 a,b).

A second, 40-g soil sample was removed from the one qt. jars after 7 days of incubation,

exposed to alcohol-free chloroform under vacuum for 24 hours and incubated with a vial with 0.3 oz. of 1 M KOH and water at 77° F for 10 days to determine soil microbial biomass C and N (Jenkinson and Powelson, 1976). Following incubation, soils were dried at 131° F, ground to pass a 2-mm sieve, and extracted with 2 M KCl (1:4 wt:vol). Samples were then shaken for 30 min. The  $\text{NH}_4^+$  content was determined from the filtered extracts by autoanalyzer techniques. Soil microbial biomass N was calculated according to the following equation:

$$\text{NH}_4^+ - \text{N}_{\text{fumigated}} \text{ minus } \text{NH}_4^+ - \text{N}_{\text{initial}} / K_{\text{N}} \text{ where } K_{\text{N}} = 0.41 \text{ (Voroney and Paul, 1984).}$$

The one-day  $\text{CO}_2$  evolution test was conducted on the total 160 g of soil (which had been wetted to 60 % field capacity) incubated from each plot (Franzluebbers et al., 1995). The vial of 1 M KOH was removed and replaced with a fresh vial after 24 hours of incubation at 77° F. Carbon dioxide-carbon respired was determined by titration (Anderson, 1982) and constituted the one-day  $\text{CO}_2$  estimate of longer-term N mineralization.

Nitrogen uptake by the forage was based on tissue N concentrations and yield. Nitrogen tissue concentrations were determined by calibrated near infrared reflectance (NIR) techniques.

Harvests in 1995 occurred on 31 March, 29 May, 21 July, 29 August, and 11 October. The first harvest was wheat in the Coastal/wheat sequence.

Since dairy manure was the sole source of N, forage N uptake in the treated plots was assumed to come from the N mineralized from manure. Nitrogen uptake in control plots was subtracted from N uptake in manure-treated plots to calculate N uptake of the mineralized N from manure. Initial inorganic N present in soil samples taken on February 17 was also assumed to be removed by the forage and was also subtracted from N uptake for uptake of mineralized N.

## Results and Discussion

Total forage N uptake and mineralized N are given in Table 1. Quantities of manure N added in this table are 75% of the total annual N additions since all soil samples and harvests occurred prior to the final quarterly manure addition, however release of N from previous addition is expected. Forage N uptake increased almost linearly with manure N added. The percentage of forage N-uptake from manure ranged from 38 to 46 % for the wheat/coastal system and from 37 to 39 % for the coastal only system and averaged 40 % overall. Some mineralization from previous years of manure addition would be expected, and therefore, these percentages are probably high.

Forage N uptake (Fig. 1) was highly correlated with laboratory soil N mineralization (Fig. 1a). This strong relationship implied that laboratory soil N mineralization might be a reliable predictor of N mineralization from dairy manure under field conditions. This laboratory procedure, however, requires a minimum of 25 days for completion.

Forage N uptake was also highly related to soil microbial biomass N (Fig. 1b). This result might be expected since microbial biomass is the agent for N mineralization and biomass N is considered a very active fraction of total soil N. This procedure, however, requires a minimum of 18 days to complete.

The one-day CO<sub>2</sub> method for estimation of N mineralization was also significantly correlated with forage N uptake (Fig. 1c). This procedure is rapid and can be conducted in less than two days and closely followed monthly N mineralization under conditions of laboratory incubation from February through September (data not shown). The flush of CO<sub>2</sub> collected for 24 hours after rewetting dried soil appeared to adequately estimate the potential of soil microbial biomass to mineralize N from organic matter when immobilization is absent (Jansson, 1958). As soil is dried and rewetted, the associated flush of CO<sub>2</sub> in 24 hours appears to accurately estimate Soil microbial biomass C and its activity (Fig. 2). Due to this relationship, one-day CO<sub>2</sub> evolution may provide an index of the potential for the soil microbial biomass to mineralize N and, therefore, estimate N availability to forage through the growing season.

The biological parameters described previously were better estimates of forage N uptake than current soil testing methods based on initial soil inorganic N from previous manure applications (Fig. 1d). This result might be expected since initial inorganic N provides a point in time estimate of plant available N and does not integrate additional N that may be mineralized with time.

### **Conclusions**

The potential exists for biological tests to enhance our ability to understand the dynamics of N mineralization and to incorporate these tests into methods useable by soil testing labs. The field conditions where our soil samples were taken for this study are very stable (Coastal bermudagrass hay meadow, regular N inputs from dairy manure). We plan to evaluate these same tests under a wider range of soils, climates, crops, and management systems to determine their usefulness under a wider range of conditions.

## Literature Cited

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Table 1. Forage N uptake of added dairy-manure N.

Cropping system	Manure N added	Initial inorganic N	Total N uptake	N mineralized	% Utilization of manure N
----- All units are lb N / ac -----					
Wheat/Coastal	0	20	45	25	---
	75	21	78	57	42
	150	21	116	95	46
	300	32	173	141	38
Coastal only	0	23	58	35	---
	75	32	95	63	37
	150	42	136	94	39
	300	36	188	152	39

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N mineralized = Total N uptake - initial inorganic N

% Utilization of manure N = ((N mineralized - control plots N mineralization)/ Manure N added)\*100

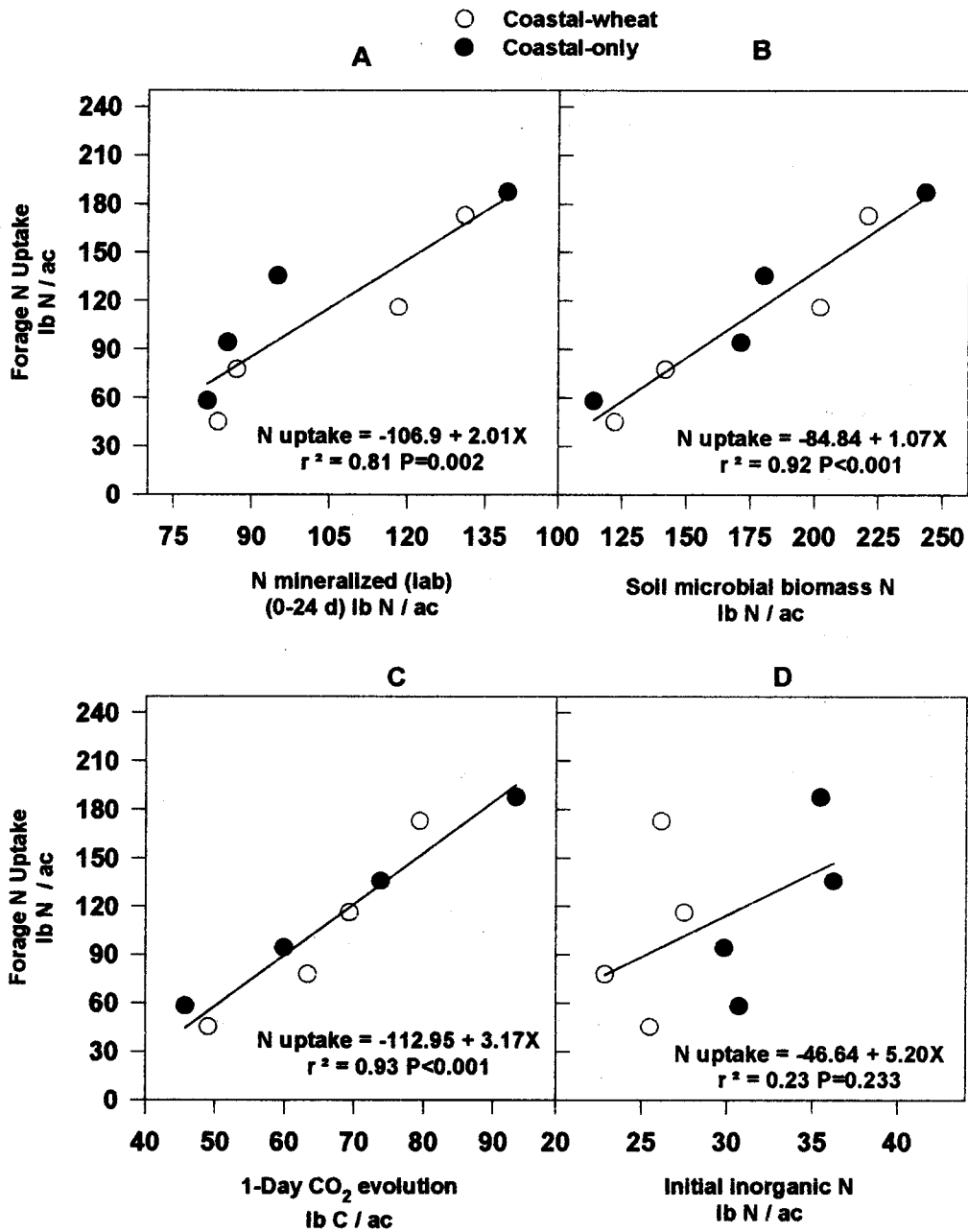


Figure 1. Forage N uptake vs, a) N mineralized during laboratory incubations (March sampling) b) soil microbial biomass N (March sampling) c) 1-Day CO<sub>2</sub> evolution from March sampling and d) initial inorganic N (NH<sub>4</sub><sup>+</sup>-N + NO<sub>3</sub><sup>-</sup>-N) from March sampling.

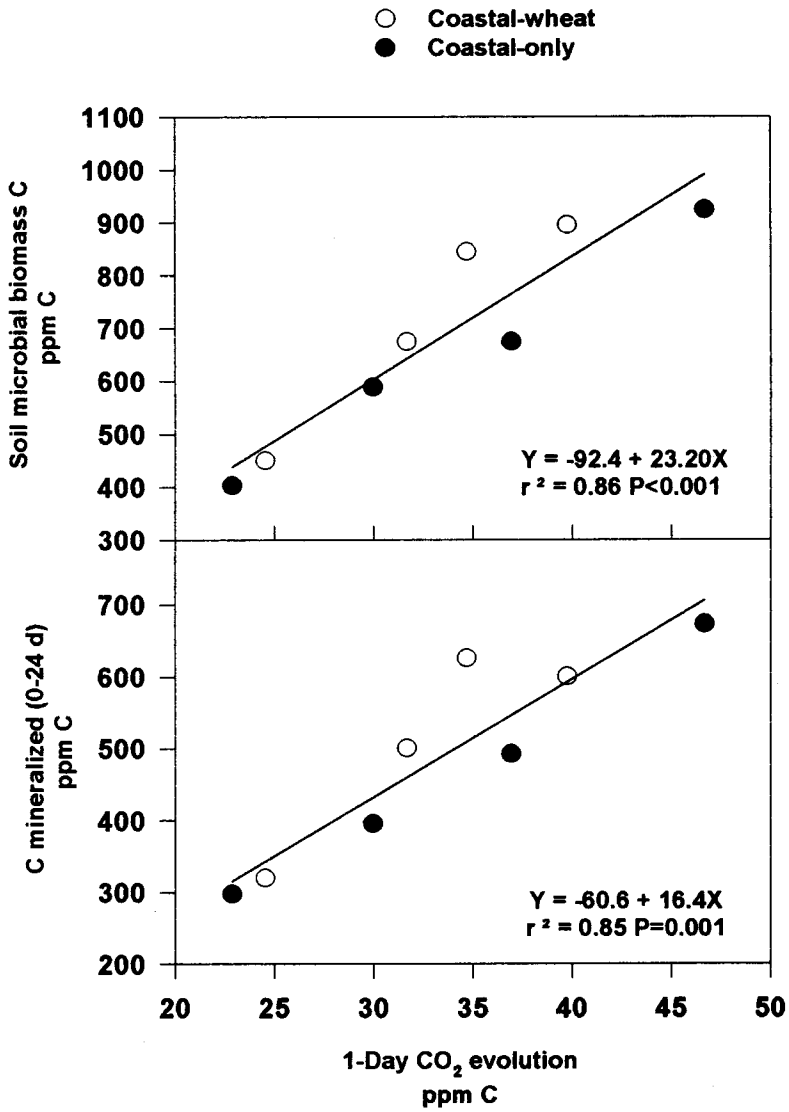


Figure 2. One-day CO<sub>2</sub> evolution vs soil microbial biomass C from the March sampling and C mineralized in a 24-d laboratory incubation from the March sampling.