Available nitrogen from animal manures

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Animal manures continue to supply available nitrogen for crops grown in California. Most of the nitrogen in manures is in the organic form and must be mineralized—converted to ammonium or nitrate forms—before it is available to plants. Thus, the rate of mineralization, or the amount mineralized in a given period, is the primary factor controlling the availability of manure nitrogen.

In a four-year field trial (1970-74) on the University of California experimental farm a few miles south of Riverside, two types of manures were used for barley grown in the winter and sudangrass grown in the summer on a Hanford sandy loam soil. One manure was a liquid material collected from a feedlot, and the other a solid material from a dairy corral.

The liquid (90 percent water) was a fresh material hauled to the site and disced into the soil within 48 hours after application. Field research showed that 75 percent of the nitrogen in this liquid was available the first year after application, whereas only 45 percent of the nitrogen from the solid manure was available in the first year. Total nitrogen in the liquid manure was 4.5 percent on a dry weight basis, so that 68 pounds of nitrogen were made available for each ton of dry weight added or from 10 tons of liquid weight. The solid manure, having 1.6 percent nitrogen on a dry weight basis, gave 14 pounds of available nitrogen per ton of dry weight or per 1.4 tons of field weight. Per ton of dry weight, the liquid manure provided almost five times more available nitrogen than the solid.

Recently collected data from a greenhouse comparison of the available nitrogen from 10 different manures are presented in the table. The data for nitrogen and carbon mineralized were obtained in laboratory incubations. The data for available nitrogen represent the total mineral nitrogen that became available in greenhouse pots cropped to barley and then sudangrass during 10 months in a San Imigdio fine sand soil. All of the manures were solids collected from various sites throughout California. All of these materials contained only traces of mineral nitrogen, so that the available nitrogen was an estimate of organic nitrogen mineralized during the 10-month cropping period.

Laboratory incubations for nitrogen and carbon mineralization were conducted at 23° C and at 60 percent saturation with water. For nitrogen mineralization, manure at a rate of 8.2 milligrams of nitrogen was added to 30 grams of soil and after water was added the mixture was incubated with constant aeration to prevent denitrification. The nitrate produced was determined by soil analysis and was corrected for nitrate produced in the nontreated soil. For carbon mineralization the manure-soil mixture consisted of 1 gram of manure and 100 grams of soil. Incubation was in a closed system constantly aerated with moist air free of carbon dioxide. The carbon dioxide evolved, corrected for that evolved from the nontreated soil, was reported as carbon mineralized.

Nitrogen Content, Mineralized Nitrogen and Carbon, and Available Nitrogen During Greenhouse Cropping

Manure type	Total nitrogen (% of dry weight)	Mineralized nitrogen* (% of total nitrogen)	Mineralized carbon† (% of total carbon)	Available nitrogen‡ %of total nitrogen	Pounds per ton dry wt.	Pounds per 15 tons field wt.§
Chicken	4.6	48	33	65	60	600
Composted chicken	1.7	29	22	35	12	120
Pig	3.9	34	28	47	37	370
Beef	2.6	23	16	40	21	210
Sheep	2.3	20	15	38	17	170
Dairy	2.9	21	16	30	17	170
Dairy	2.0	9	10	24	10	100
Composted dairy	2.0	6	5	21	8	80
Composted dairy	1.9	6	5	14	5	50
Composted dairy	2.1	5	2	6	2	20

*Nitrogen mineralized in 10 weeks of incubation in the laboratory.
†Carbon mineralized in 1 week of incubation in the laboratory.
‡Nitrogen available during 10 months of cropping in the greenhouse.
§Pounds available nitrogen for a 15-ton application, assuming a field weight of 67 percent solids and 33 percent water.

There was a high correlation between nitrogen mineralized in the laboratory and nitrogen available in the greenhouse pots ($Y = 8.47 + 1.16 X$, $r = 0.95$) and between nitrogen available and carbon mineralized ($Y = 7.77 + 1.56 X$, $r = 0.95$) indicating that nitrogen mineralization is associated with the ease with which microorganisms decompose the carbon in the manures.

The last column in the table shows the pounds of nitrogen available from a 15-ton application of field weight, assuming 33 percent water. Obviously, 15 tons of the fresh chicken manure with 4.6 percent nitrogen is too much. A 5-ton application would be more appropriate for most situations, but for the composted chicken manure the 15 ton application is needed to supply even a modest amount of available nitrogen. On the other extreme from fresh chicken manure is the composted dairy manure, which provided only 20 pounds of available nitrogen for a 15 ton application.

The data from the field trial and from the greenhouse show that the nitrogen available from manures depends on the type of animal, the nitrogen content, and the stability of the nitrogen or the ease with which it is mineralized. For a given type of animal, the factors are nitrogen content and the stability of that nitrogen. Manures aged by wetting and drying as they accumulate on corral floors or under pens or coops lose nitrogen by volatilization of ammonia; the remaining nitrogen is more stable or resistant to mineralization. The extreme of this stabilization process takes place during composting. The aging or composting process produces manures with low odors and good physical properties, but with lower nitrogen availability. Thus the ideal manure management for optimizing nitrogen availability is to apply the manure and mix it with the soil as soon as it is produced. The longer the time between production and incorporation, the lower the available nitrogen.

The data in the table are used to illustrate the factors involved in nitrogen availability and should not be used to estimate the nitrogen available from any given product for which nitrogen and water contents and ease of mineralization are not known.

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