Nitrogen Release From Natural Organic Turf Fertilizers

By Jeffrey K. Barlow

Selection and effective use of natural organic turf fertilizers requires knowledge of the rate at which microbial action converts the organic N to inorganic N. This process, hereafter referred to as organic N mineralization, is influenced by a number of factors. One is the composition of the fertilizer. As a general rule, the more complex the organic compounds present, the slower their rate of decomposition and release of inorganic N. Fresh plant and animal residues, with their sugars and amino acids, decompose more quickly than organic materials that have already undergone some degree of microbial decay.

Level of microbial activity per se is another important consideration. Microorganisms, like all living biota, require a moist environment and are temperature responsive. The optimum temperature for microbes thought to be instrumental in organic fertilizer decay is around 90° F. Also of some concern is the microbe population. Although actively growing turf teems with microorganisms, there exists the view that heat sterilized natural organic fertilizer decomposition is delayed by the time required for the population of microbes to build up. Presumably this is not true for non-sterilized fertilizers.

A final variable in N mineralization is particle size of the natural organic fertilizer. Microbial attack is viewed as a surface phenomenon. If so, then the anticipation is that smaller particles, because of their greater amount of surface area per unit weight or volume, decompose more quickly than do larger particles.

The purpose of the present study was to examine how the various factors mentioned above influence the rate of organic N mineralization from different types of natural organic fertilizers. To do this, the fertilizers listed in Table 1 were applied at the rate of 1.5 lb N/M to the surface of 50 g of an 80/20 sand-peat mix contained in incubation funnels. A moisture content of 14.7% was established by adding water and then applying a 20-cm suction for five minutes.

The incubation funnels were enclosed in plastic bags to retard drying and incubated at 68° or 90° F for periods of 7, 14, 28, and 42 days. At the end of each incubation period inorganic N was extracted with 40 ml of 0.004 N $CaCl_2$ solution. Inorganic N (nitrate + nitrite + ammonium) was determined by way of steam distillation and titration.

RESULTS AND DISCUSSION

Fertilizer Properties

The amount of information that manufacturers are required by law to place on bags of natural organic fertilizers is minimal. To extend our knowledge of these fertilizers, the products used in the present study were subjected to various types of analyses. General properties of the fertilizers are shown in Table 1. The first three, Milorganite, Hou-Actinite and Fërorganic, are sewage sludge products. Sustane is composted turkey droppings plus pine bark bedding. The 5-3-1 fertilizer is a Spring Valley product consisting of a blend of Milorganite and chicken manure compost. Hynite and Lorganic-8 are leather scrap products. The Hynite is palletized ground leather scraps and Lorganic-8 is a liquid fertilizer made by solubilizing leather scraps and removing the metals used in the tanning process.

TABLE 1. General characteristics of the natural organic fertilizers used.

Fertilizer	Physical state †	Organic matter Δ	Moisture content	Total N content As is	Total N content Oven-dry	Inorganic N
		%				
Milorganite 6-2-0	R	71.0	10.6	5.64	6.24	0.74
	G	71.0	10.1	5.82	6.41	0.72
	F	73.4	23.0	6.08	7.48	0.86
Hou-Actinite 5-2-0	R	67.1	5.2	6.26	6.58	0.67
	G	61.0	3.9	5.54	5.76	0.58
Fororganic 6-3-0	R	71.6	8.1	5.51	5.95	4.90
Sustane 5-2-4	R	47.4	9.3	4.74	5.18	0.54
	F	43.8	11.5	4.10	5.06	8.76
5-3-1	R	65.9	10.2	5.28	5.82	5.43
	R(1)	65.9	10.3	5.38	5.88	5.15
	R(2)	65.3	9.1	5.38	5.87	5.26
Hynite 11-0-0	R	87.8	8.1	11.66	12.60	1.22
Lorganic	L	97.7	—	7.81	—	0.46

† R = regular grade; G = Greens grade; F = fine; R(1) = 1% mold culture added; R(2) = 2% mold culture added; L = liquid.

Δ Determined as weight loss upon ignition at 600°C.

§ Percent of total N.

The first thing to notice in Table 1 is the wide variability among the fertilizers in their organic matter, moisture and inorganic N contents. The Lorganic-8 is essentially 100% organic while Sustane contains only about 45% organic matter. Moisture contents of the fertilizers as they came from the bag ranged from 3.9 to 23%. Inorganic N levels were less than 1% in the sewage sludge products but were as high as nearly 9% in the fine grade Sustane. Past analyses have shown Sustane to contain as much as 24% inorganic N. Clearly, this wide variability in inorganic N content will have an impact on the rate of turfgrass greenup by the various natural organic turf fertilizers.

Because of their plant and/or animal origin, natural organic fertilizers contain virtually all of the essential plant nutrients. These are not reported because the amounts are typically too low to permit listing under existing fertilizer laws. They can, however, become significant with repetitive, long-term use of a particular fertilizer. As shown in Table 2, the fertilizers studied do vary considerably in their plant nutrient contents. For example, even though Milorganite and Fororganic are both sewage sludge fertilizers, the Fororganic contains 4 times as much Ca and nearly twice as much S as does the Milorganite.

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TABLE 2. Essential plant nutrient contents of the natural organic fertilizers used. †

Fertilizer	N	P_2O_5	K_2O	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	Nutrient content										
	%						ppm				
Milorganite	6.71	3.17	0.36	0.83	0.37	0.80	16.2	296	59,300	160	687
Hou-Actinite	6.17	4.52	0.37	1.85	0.30	0.67	14.9	258	20,700	169	687
Flororganic	5.95	4.59	0.12	3.72	0.22	1.33	16.6	558	8,580	68	849
Sustane	5.12	4.07	3.70	3.80	0.71	1.68	37.5	214	14,700	322	597
5-3-1	5.86	3.68	1.86	5.63	0.58	0.73	21.0	182	38,400	272	544
Hynite	12.60	0.09	<0.01	.066	0.10	2.06	9.1	40	1,070	11	23
Lorganic-8	7.81	<0.01	<0.01	0.58	<0.01	0.04	3.7	13	89	1	6

† Means for the various size grades.

A concern that sometimes arises with natural organic fertilizers compounded from waste materials is their heavy metal content. The fertilizers used in the present study varied considerably in this regard (Table 3). However, with exception of the 29,500 ppm chromium and 2,480 ppm selenium in Hynite, the levels of heavy metals in all the other fertilizers are so low as to meet EPA standards for application on food crops as well as turf.

TABLE 3. Heavy metal contents of the natural organic fertilizers used. †

Fertilizer	Arsenic	Cadmium	Chromium	Nickel	Lead	Selenium
	Heavy metal					
	ppm					
Milorganite	<28	16.1	656	47.5	155	24
Hou-Actinite	<28	10.7	84	25.2	66	<19
Flororganic	<28	9.0	64	26.0	102	<19
Sustane	<28	2.3	28	18.5	<11	<19
5-3-1	<28	6.9	396	<22	89	113
Hynite	35	<1	29,500	<4	11	2,480
Lorganic-8	<28	<1	43	<4	11	<19

† Means for the various size grades.

Nitrogen Mineralization

Temperature was understandably one of the most important factors affecting organic N mineralization rates. This was evidenced by the fact that organic N mineralized in 42 days averaged 23% higher at 90°F as compared to 68°F (Table 4). This 1.8-fold difference in N mineralization emphasizes the point that turfgrass response to natural organic fertilizers is typically very temperature sensitive. This generalization did not, however, hold true for Lorganic-8. The amount of inorganic N released from this product was nearly as great at 68°F as at 90°F.

Another way of characterizing the sensitivity of N mineralization from natural organic fertilizers to temperature is to examine the percent increase in N mineralization per 10° rise in temperature. As shown in Table 4, these values ranged from a low of 3.2 for Lorganic-8 to a high of 15.9 for the 5-3-1 fertilizer not inoculated with mold culture. The higher these values, the greater the sensitivity of organic N mineralization to temperature.

Composition effects on the amounts of organic N mineralized in the 42-day incubation were nearly as great as temperature effects when the fertilizers were incubated at 68°F (Table 4). Examples of this are the 23% more N released from Milorganite F as compared to Fلororganic and 36% more N released from Lorganic-8 as compared to the Flororganic. Incubation of the fertilizers at 90°F greatly diminished fertilizer composition influences on organic N mineralization.

The effects of fertilizer particle size on organic N mineralization were likewise considerably greater at 68° than at 90°F (Table 4). In fact, at 90°F particle size effects were not only small but erratic as well. This was most evident in the Milorganite treatments. At 68°F, going from the regular to fine grade of Milorganite increased organic N mineralization 16%. But at 90°F, mineralization of organic N was 5% less from the fine grade rather than the regular grade of Milorganite.

TABLE 4. Organic N mineralized during a 42-day laboratory incubation and percent increase in mineralization per 10oF temperature increase.

Fertilizer	Physical state †	Organic N mineralized 68°F	Organic N mineralized 90°F	Increase in mineralization
Milorganite	R	26.0	55.8	13.5
	G	33.1	51.7	8.4
	F	36.6	51.0	6.5
Hou-Actinite	R	29.4	53.4	10.9
	G	29.7	47.5	8.1
Flororganic	R	13.6	34.5	9.5
Sustane	R	37.8	59.8	10.0
	F	20.7	43.0	10.1
5-3-1	R	15.3	50.2	15.9
	R(1)	20.6	49.8	13.3
	R(2)	21.4	52.2	14.0
Hynite	R	31.5	58.7	12.4
Lorganic-8	L	49.9	56.9	3.2

† R = regular grade; G = greens grade; F = fine; R(1) = 1% mild culture added; R(2) = 2 % mold culture added; L = liquid.

Inoculation of the 5-3-1 fertilizer with mold culture slightly increased organic N mineralization at 68°F but not at 90°F (Table 4). The maximum increase in organic N mineralization that resulted from microbial inoculation of the fertilizer was 6.1%.

Cumulative release of the organic N from the fertilizers when incubated at 68°F is illustrated in Figure 1. Similar N release patterns were observed at 90°F. The patterns of N release are essentially the same for all but Hynite. Mineralization was rapid and essentially linear with time for the first 14 days and then leveled off. This pattern of N release is typical. It reflects that fact that natural organic fertilizers contain a wide array of compounds that vary in their susceptibility to microbial decomposition. Simpler compounds such as amino acids and proteins decompose rapidly, leaving behind N-bearing compounds whose decay rate is much lower.

The initial delay in N mineralization from Hynite (Figure 1) is believed have resulted from the physical state of the fertilizer. The fertilizer pellets are large, showed no sign of disintegration during the first 7 days of incubation, and very small quantities of N were mineralized. Once pellet disintegration began, N mineralization increased markedly to rates comparable to those for the other natural organic fertilizers. At the end of the 42 day incubation period, the N mineralization rate for Hynite was greater than for the other fertilizers.

Thus, it is possible that if the incubation time had been extended beyond 42 days, the amount of N mineralized from Hynite may have approached that of Sustane.

Non-cumulative N mineralization is an important property of natural organic N fertilizers because it shows whether or not different fertilizers release N at different time after application. As shown in Figure 2, mineralization of N from Milorganite, Hou-Actinite and Lorganic-8 peaked at 7 days. The peak in N mineralization for Sustane occurred at about 14 days and for Hynite at 28 days. These differences in N mineralization patterns suggest that turfgrass greenup would be quickest for a fertilizer such as Milorganite and slowest for Hynite. On the other hand, one might expect that turfgrass color retention times would be longer for Sustane or Hynite than for the sewage sludge fertilizers.

Among the fertilizers studied, Lorganic-8 displayed a distinctive N mineralization pattern (Figure 1). Mineralization of N was high the first 7 days, dropped somewhat between days 7 and 14, and then held steady between days 14 and 28. This suggests that the product may provide both quick greenup and better than average turfgrass color retention times.

CONCLUSIONS

The results of this study show that while temperature exerts a major influence on the rate of organic N mineralization from natural organic fertilizers, other factors may have to be considered as well. At temperatures that are not optimal for microbial activity, fertilizer composition and particle size effects can be as great as temperature effects. Different fertilizers display different temperature sensitivities and particle size effects vary with the particular fertilizer applied. Mineralization of N from Lorganic-8 was observed to be quite temperature insensitive. Particle size effects on N mineralization were evident for Milorganite, did not exist for Hou-Actinite, while reducing particle size actually seemed to adversely affect N release from Sustane.

At optimal temperatures for microbial activity, the influences of fertilizer composition, particle size and microbe inoculation on organic N mineralization rates were greatly reduced. Thus, choice of natural organic fertilizer is much less an issue when application is being made in the summer months as compared to spring and fall. The same cannot be said when good turfgrass color response is expected from early spring and late season applications of natural organic fertilizers.

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Figure 1. Cumulative organic N mineralized at 68°F from several natural organic turf fertilizers

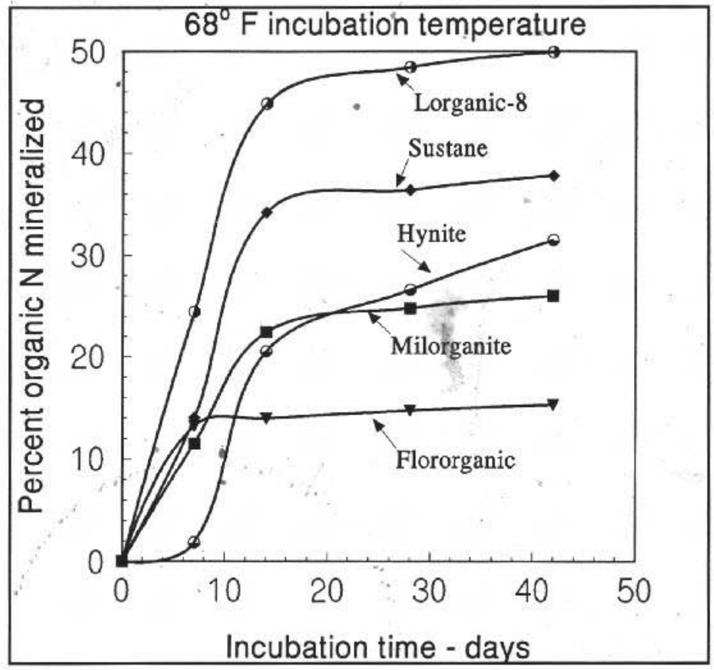

Figure 2. Organic N mineralized from several natural organic turf fertilizers incubated at 90°F