Nitrogen-mineralization potential of meadow soils

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Simard, R. R. and N'dayegamiye, A. 1993. **Nitrogen-mineralization potential of meadow soils.** Can. J. Soil Sci. **73**: 27–38. An understanding of the mineralization factors in contrasting cultivated soils is necessary for accurate predictions of plant-available N. The objective of this work was to determine the N-mineralization potential and mathematical models that can properly describe the dynamics of the mineralization process in 20 meadow soils from Quebec. The mineralization was monitored over 55.4 wk in a laboratory incubation at 20°C with intermittent leaching. The cumulative mineralization curves in most soils were characterized by definite lags or a sigmoidal pattern and near-linear release with time after 20 wk. The data were best described by the Gompertz equation; first-order models were inadequate. The total amount of mineralizable N and the potential mineralization rate were very closely correlated with the total amounts of C or N ($r > 0.73$; $P < 0.01$). The clay content was also correlated with these mineralization parameters and significantly improved the prediction of the cumulative and potential N-mineralization rate estimated from the total N or C content of soils. The relationships with other soil characteristics such as soil pH and available nutrient contents were weak but significant. The results of this study suggest that textural classes be added in the correction for organic matter content to improve the precision in N-fertilizer recommendation and in soil-quality classifications based on potential mineralization rate.

Key words: Soil quality, potentially mineralizable N, Gompertz equation, soil organic matter, soil texture, C, N

Simard, R. R. et N'dayegamiye, A. 1993. **Potentiel de minéralisation des sols de prairie.** Can. J. Soil Sci. **73**: 27–38. La connaissance des facteurs reliés à la minéralisation de l'azote dans différents sols est essentielle pour une meilleure prédiction de la teneur en azote potentiellement assimilable par les végétaux. L'objectif de ce travail consistait à déterminer le potentiel de minéralisation de l'azote et à identifier un modèle mathématique décrivant adéquatement les données pour 20 sols du Québec sous prairies permanentes. Nous avons effectué une étude d'incubation prolongée sur une période de 55,4 semaines à 20°C, et le N minéralisable était déterminé au moyen de lessivages intermittents. Les courbes de minéralisation cumulative sont caractérisées, dans la plupart des sols, par des délais ou des patrons sigmoïdaux et par une libération plus ou moins linéaire avec le temps après 20 semaines. Les données ont été décrites le plus adéquatement par l'équation de Gompertz alors que les modèles de premier-ordre étaient inadéquats. Des corrélations très étroites ($r > 0,73$; $P < 0,01$) ont été établies entre la quantité totale d'N minéralisable et le taux initial potentiel de minéralisation d'une part, et d'autre part, les teneurs en N ou C total des sols. Les fractions granulométriques étaient aussi corrélées avec les paramètres de minéralisation, ce qui n'était pas le cas du pH et des teneurs en éléments nutritifs. En effet, l'ajout de la teneur en argile en régression multiple a amélioré grandement la prédiction du taux initial potentiel de minéralisation et de la minéralisation totale de l'azote par la teneur en C ou N des sols. Les résultats de cette étude suggèrent de tenir compte des classes texturales afin de complémenter la teneur en matière organique des sols dans les recommandations de fertilisation azotée des cultures ainsi que dans la classifications de la qualité des sols basées sur le taux initial potentiel de minéralisation.

Mots clés: Qualité des sols, potentiel de minéralisation de l'azote, équation de Gompertz, matière organique, texture, C, N.

The N mineralized from organic matter (OM) often contributes a major proportion of the soil N available to plants. Our ability to measure and predict N availability to plants is increasingly important, even though this still presents difficulties. Indigenous available N is derived mainly from mineralization of soil OM (Biederbeck et al. 1984). Consequently, the N-mineralization potential of soils has to be taken into account in computer-assisted management systems that aim to improve the efficient use of N fertilizers (Richter et al. 1988). The initial potential rate of N mineralization has been proposed as a criterion for the definition of soil OM quality (Campbell et al. 1991).

Some studies have shown that the N-mineralization potential is closely related to the total amounts of organic N and C in soils (Cabrera and Kissel 1988), but other studies have reported no such relationships (Tabatabai and Al-Khafaji 1980). Giroux and Sen Tran (1987) compared some chemical extraction methods versus short incubation at 35°C for estimating soil mineralizable N in relation to plant N uptake. The soil N-mineralization potential has been shown to be affected by climatic factors such as moisture supply and temperature (Cassman and Munns 1980; Myers et al. 1982). The rate of N mineralization is dependent on cropping practices (Campbell and Souster 1982; El-Harris et al. 1983), tillage intensity (El-Harris et al.), crop residues (Smith and Sharpley 1990) and fertilizer applications (Janzen 1987). In addition, some soil characteristics such as texture (Herlihy 1979; Campbell and Souster 1982), pH (Schmidt 1982), C:N ratio (Harmsen and Van Schreven 1955) and NH_4 retention capacity (Kowalenko and Cameron 1976) have been related to the amount of N mineralized in long-term incubation experiments. Even though all of these factors have been recognized as important, very limited information is available on the influence of these soil properties on the initial potential rate of N mineralization in a wide range of soils, particularly in eastern Canada.

The mathematical description of the dynamics of N mineralization in long-term incubation studies is of great interest. A first-order equation introduced by Salter and Green (1933) has been used most frequently to describe the mineralization of soil organic N. Using non-linear techniques, the first-order equation was modified to take into account easily mineralized (Beauchamp et al. 1986) and less easily mineralized N fractions (Richter et al. 1982). Other researchers have found that a zero-order equation more adequately describes N mineralization (Tabatabai and Al-Khafaji 1980; Addiscott 1983). The mineralization curves are sometimes characterized by a lag phase followed by a subsequent increase in mineralization rate that can be associated with sigmoidal patterns of growth curves (Hadas et al. 1986). Several models have been recently evaluated to describe this type of behavior (Ellert and Bettany 1988). For accurate predictions of soil N availability to plants, it is important that we select a model that will simulate the behavior of N mineralization for a wide range of soils. The parameters derived could be further related to other soil characteristics to improve the estimation of the contribution of mineralized N to the crop needs.

The objectives of this study were (*i*) to determine N-mineralization potential of 20 meadow soils, (*ii*) to describe the mineralization data using various equations, and (*iii*) to statistically relate the measured and calculated N-mineralization parameters to selected chemical and physical properties of these soils.

MATERIALS AND METHODS

Soil Analysis

Twenty surface-soil samples (0–20 cm) representing a wide range of pH, OM content, nutrient status, cation-exchange capacity and clay contents were collected from pastures in different regions of Quebec (Table 1). The soils were screened under field-moist conditions to pass through a 6-mm sieve and kept at 4°C for 2 wk prior to the beginning of the incubation experiment.

Particle-size distribution was determined on subsamples of each soil by mechanical dispersion of the samples after OM decomposition with H_2O_2. Sand, silt and clay contents were then determined

Table 1. Classification and selected chemical and physcial properties of 20 meadow soils

Soil			Organic				Mehlich 3-extractable ($mg\ kg^{-1}$)			
Series	Classification[z]	pH	carbon ($g\ kg^{-1}$)	Sand (%)	Clay (%)	Total N ($g\ kg^{-1}$)	P	K	Ca	Mg
Soil group A (n = 8)										
Saint-Jude	O.HFP	6.4	10	91	6	0.86	118	108	778	60
Beaurivage	O.HPF	6.1	30	59	9	1.80	58	36	1170	39
Saint-André	O.HFP	5.3	36	34	33	3.00	67	149	908	150
Alma	O.HG	6.0	31	7	45	2.43	18	68	1287	78
Morin	O.HFP	6.2	24	91	9	2.04	66	544	726	195
Chicoutimi	O.HG	5.8	48	3	47	3.36	22	325	1756	138
Chapeau	O.HG	5.7	31	28	23	2.19	28	386	887	159
La Barre	O.HG	6.5	15	59	22	1.08	20	49	1024	173
Soil group B (n = 7)										
La Pocatière	O.HG	6.5	15	11	41	1.32	40	148	3231	328
Le Bras	O.HG	5.4	17	81	6	1.08	15	29	76	84
Pontiac	O.HG	5.8	43	23	32	3.00	22	89	1376	111
Larouche	O.HG	6.6	35	19	31	2.61	26	222	3185	186
Normandin	O.HG	6.4	17	4	43	1.51	44	107	1618	411
Taillon	GL.SB	6.3	47	29	36	3.15	41	600	2021	191
Hébertville	O.HG	7.3	30	0	60	2.14	21	167	5703	286
Soil group C (n = 5)										
Girard	GL.HFP	6.9	21	81	6	1.38	59	188	1989	55
Parent	O.HFP	5.9	17	70	8	1.23	107	58	369	28
Godfroy	GL.GL	5.7	25	72	16	1.85	103	319	1039	195
Chaloupe	O.HG	6.1	26	72	11	1.95	142	124	1398	53
Dolbeau	O.HFP	6.9	7	77	1	0.48	22	21	580	13

[z] O.HG, Orthic Humic Gleysol; GL.SB, Gleyed Sombric Brunisol; O.HFP, Orthic Humo-ferric Podzol; GL.HFP, Gleyed Humo-ferric Podzol; GL.GL, Gleyed Grey Luvisol (Canada Soil Survey Committee 1987).

by the hydrometer method (Gee and Bauder 1986). Soil pH was measured in water with a soil/water ratio of 1:1. The organic C content was determined by wet oxidation using $K_2Cr_2O_7$, H_2SO_4 and H_3PO_4 (Allison 1965). Total N was obtained by Kjeldahl digestion (Bremner 1965). The bioavailable P, K, Ca and Mg were extracted using the Mehlich 3 solution (Mehlich 1984), and the nutrient content of the extracts was determined by inductively coupled plasma spectroscopy.

Incubation Studies

Field-moist samples, each 400 g, were put in 4-L plastic tubes to insure optimum aeration and microbial activity. Demineralized water was added to a predetermined content at −33 kPa. The samples were incubated at 20°C. Mineral N was recovered every 1.4 wk by leaching with a N-free solution of 0.001 *M* $CaCl_2$ under −400-kPa suction (Stanford and Smith 1972). After 5.7 wk, the soils were leached at 2-wk intervals for a total incubation period of 55.4 wk. The leachates were analyzed for their nitrate, nitrite and NH_4^+ contents by liquid chromatography using a Dionex 4000i apparatus and a conductivity detector. The determination of NH_4^+ and nitrite was abandoned after the first three leachings, since no significant amounts were found despite verifications every two samplings.

Data Analysis

The N-mineralization data were described using two methods: zero-order kinetics and the Gompertz equation (France and Thornley 1984).

Zero-order kinetics is given by the following:

$$N_m = b_o + (kt)$$

where N_m is the cumulative amount of mineralized N (mg kg^{-1}); t is the time (wk); and k is the rate constant (mg kg^{-1} wk^{-1}).

The Gompertz equation is the following:

$$N_m = N_o e^{-he^{-kt}} - N_o e^{-h}$$

where N_m and t are as described above; N_o is the amount of potentially mineralizable organic N (mg kg^{-1}); k is the rate constant (wk^{-1}); and h is a proportionality constant of the equation. This equation may be derived on the following assumptions: the substrate is not limiting; the mineralization rate increases in the early stages; and the efficiency of the release process will decrease with time because of the slower activity of the mineralizing flora or the exhaustion of the mineralizable N. This third assumption is described by the proportionality factor (h).

The nitrogen mineralization potential was also estimated by the first-order model (Stanford and Smith 1972), a modified form of the first-order model (Beauchamp et al. 1986), and a mixed first-order, two-component model (Bonde and Lindberg 1988). In the present study, these last three models were not found to be as useful for all soils, and calculations generated will not be presented. An NLIN procedure using the multivariate secant method from a Satistical Analysis System Institute, Inc. (1985) software package was followed to solve the Gompertz equation.

RESULTS

Nitrogen Mineralization

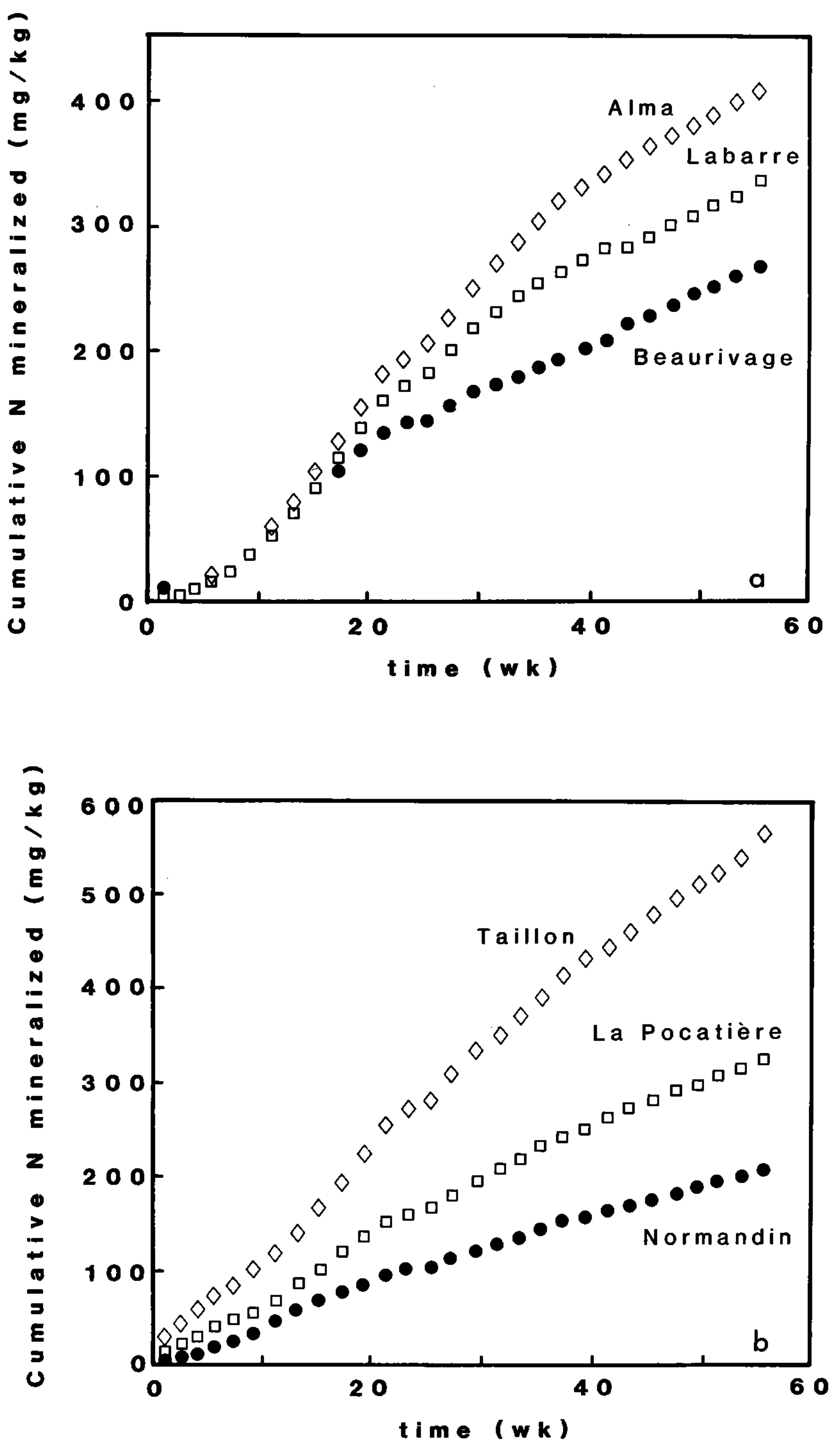
The soil groupings in Tables 1 and 2 were made based on difference in N release patterns. The total amount of N mineralized (N_m) ranged between 100 and 587 mg kg^{-1} and constituted 11.3–31.0% of the total soil N (Table 2). The easily mineralizable fraction (N_e), which is the amount of N mineralized over 10 d, ranged between 1.1 and 59.8 mg kg^{-1}. These amounts of N_e are in the range obtained for comparable soils in eastern Canada when they were incubated at 25°C (Drury et al. 1991), but they are in the low range compared with other studies in which incubation was at 35°C (Eagle and Matthews 1958; Giroux and Sen Tran 1987).

The accumulated net N mineralized for some of the soils is shown in Fig. 1. The cumulative N mineralization followed three distinct patterns: eight soils showed a delay phase, followed by a maximal rate phase, and a final decreasing rate phase that is generally like a sigmoidal growth curve (Fig. 1a; group A, Table 2); seven soils showed a generally linear increase with time throughout the whole period of incubation (Fig. 1b; group B, Table 2); and five soils showed an extended delay phase followed by a linear to almost linear phase with time (Fig. 1c; group C, Table 2). Sigmoidal release patterns have been previously reported (Hadas et al. 1986; Ellert and Bettany 1988; Dendooven et al. 1990). Most of the podzolic soils showed a definite lag in the early part of the incubation. This lag could originate from the

Table 2. Nitrogen-mineralization characteristics including N mineralized over the 388-d incubation (N_m), easily mineralized N over 10 d (N_e), potentially mineralizable N (N_o), h and k parameters of the Gompertz equation, and b_o and k parameters of the zero-order equation

				Gompertz					Zero-order		
Soil	N_m (mg kg^{-1})	N_m/N_{tot} × 100	N_e (mg kg^{-1})	N_o (g kg^{-1})	h	k (10^{-2} wk^{-1})	SEE	N_ok[z]	b_o (mg kg^{-1})	k (mg kg^{-1} wk^{-1})	SEE
				Soil group A (n = 8)							
Saint-Jude	203	23.6	56.7	478	3.18	2.12	31	10.1	40.4	2.84	14
Beaurivage	267	14.8	8.2	269	3.21	6.11	25	16.4	6.3	4.93	459
Saint-André	587	19.6	36.0	915	1.58	4.07	167	37.3	31.5	10.91	1436
Alma	407	16.7	2.2	433	4.51	7.77	32	33.6	−15.5	8.71	1404
Morin	263	12.9	59.8	356	1.67	2.77	274	9.9	64.9	3.44	369
Chicoutimi	525	15.6	9.6	647	2.51	5.41	45	35.0	9.0	10.2	1184
Chapeau	388	17.7	4.0	489	3.36	5.08	26	24.8	−19.8	7.67	354
La Barre	335	31.0	1.1	351	3.81	7.28	26	25.6	−4.3	6.67	354
				Soil group B (n = 7)							
La Pocatière	327	24.8	12.9	576	1.54	3.29	12	18.9	8.8	6.04	185
Le Bras	154	14.2	12.7	202	2.85	3.66	18	7.4	2.4	2.69	24
Pontiac	375	12.5	14.7	813	1.79	2.43	15	19.8	0.9	6.87	97
Larouche	360	13.8	4.4	469	3.09	4.81	19	22.6	−14.2	7.04	398
Normandin	208	13.8	1.1	375	1.49	3.13	12	11.7	3.6	3.84	127
Taillon	568	18.0	27.1	1098	1.45	2.89	102	31.7	17.5	10.27	1236
Hébertville	409	19.1	5.3	551	1.96	4.82	21	26.6	16.5	7.69	96
				Soil group C (n = 5)							
Girard	195	14.1	26.2	456	4.86	2.92	4	13.3	0.2	3.15	367
Parent	142	11.5	2.2	202	3.36	4.24	16	8.6	−9.7	2.76	56
Godfroy	349	18.9	27.1	656	2.48	2.97	109	19.5	−7.1	6.42	297
Chaloupe	221	11.3	12.9	480	2.66	2.60	55	12.5	−8.8	4.04	632
Dolbeau	100	20.8	2.2	129	2.96	4.92	14	6.3	−3.2	1.96	176

[z]Initial mineralization potential.


Cumulative N mineralized (mg/kg)
time (wk)
Alma
Labarre
Beaurivage
a
Taillon
La Pocatière
Normandin
b

stimulation of microbial biomass as soil pH is increased by leaching with a solution of 0.001 M $CaCl_2$ (Stanford and Smith 1972). Short-term nitrification rates have been reported to be linearly related to soil pH in other soil types (Dancer et al. 1973; Gilmour 1984). However, two of the podzolic soils (Girard and Dolbeau series) had pH values close to neutrality (Table 1) and showed definite lags (Fig. 1c).

Calculation of Potentially Mineralizable Nitrogen

The zero-order equation was fitted to the data (Table 2). Large values of the standard error of estimate (SEE) were obtained, particularly for group A soils. The Gompertz equation described the data best: it obtained much smaller values of SEE than the zero-order model. It was previously shown to describe adequately the cumulative release of N from a Grey Luvisol under a wheat–fallow cropping sequence (Ellert and Bettany 1988).

The range of N_0 values obtained by the Gompertz equation ranged was 129–1098 mg kg^{-1} and represented 14.9–43.6% of total soil organic N (Table 2). If the length of the incubation is taken into consideration, the range of N_0 and proportion of total N are comparable to those obtained from forest soils (Fyles and McGill 1987) and agricultural soils (Stanford and Smith 1972; Janzen 1987; Campbell et al. 1991). The range of the rate constant (k) values calculated with this model was 0.0212–0.0777 wk^{-1}. These values are larger than those obtained in forested soils (Fyles and McGill) and comparable to those obtained by others (Stanford and Smith; Herlihy 1979) but less than those obtained in prairie (Biederbeck et al. 1984; Janzen; Campbell et al.) and Ontario soils (Beauchamp et al. 1986). The value of k has been reported to be dependent on climate, on the method of calculation, and on the length of the incubation (Paustian and Bonde 1987; Campbell et al.). Long periods of incubation

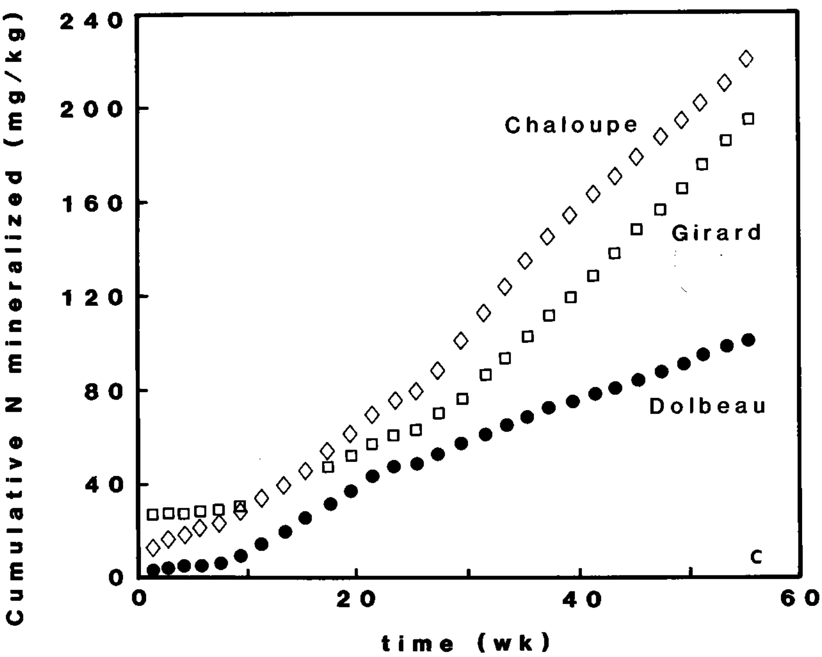


Fig. 1. Cumulative N-mineralization patterns at 20°C: (a) a delay phase, followed by a maximal rate phase, and a final decreasing-rate phase that is generally like a sigmoidal growth curve; (b) a generally linear increase with time throughout the whole period of incubation; and (c) an extended delay phase followed by a linear to almost linear phase after 20 wk.

have been previously shown to result in lower and less variable k values (Paustian and Bonde). Differences in methodology, such as the temperature of incubation, also have an influence on this rate constant (Addiscott 1983; Campbell et al. 1984). The long incubation period and the low temperature of incubation (20°C) probably explain the low values of k obtained, although the temperature of incubation used in the present study better reflects the mean temperature of soils measured at 1-cm depth during the growing season, under meadow, in the climate of Quebec (Ouellet et al. 1975).

Campbell et al. (1991) calculated an initial potential rate of N mineralization that is the product of N_o and k at time 0 as a criterion for assessing soil quality. The range of calculated values of N_ok was 7.4–37.3 mg kg^{-1} wk^{-1}. The values were, on average, less for podzolic soils (14.6 mg kg^{-1} wk^{-1}, n = 7) than for gleysolic ones (21.6 mg kg^{-1} wk^{-1}, n = 10). Only soils with organic C contents greater than 35 g kg^{-1} (Tables 1 and 2) showed values of initial potential rate in the range obtained by Campbell et al. for prairie soils. These soils with large OM contents are considered very productive in Quebec. The N_ok value is an indication of the soil-N-supplying capacity to plants.

Relationships between Calculated and Measured N-Mineralization Parameters

The linear correlations between measured and calculated mineralization parameters are given in Table 3. The total amount of N mineralized (N_m) was closely correlated with N_o (r = 0.84**), and with the initial potential rate of mineralization (N_ok, r = 0.95**). The N_e fraction was inversely related to the rate constant of the Gompertz equation (r = −0.60**). Estimates of N_o and of the rate constant k were not significantly correlated (r = 0.30). Significant inverse relationships have been observed between these two parameters when calculated with the first-order equation (Beauchamp et al. 1986; Paustian and Bonde 1987; Campbell et al. 1991). These results show the definite advantage of the Gompertz equation over the classical form of the first-order kinetic equation.

Relationships between N-Mineralization Parameters and Selected Soil Characteristics

The linear correlations between N-mineralization parameters and some selected chemical and physical soil characteristics are presented in Table 4. The total amount of N mineralized was very closely related to the total amount of N (r = 0.86**), the total amount of organic C (r = 0.81**), and the clay content of the soils (r = 0.69**). Correlation coefficients of the relations between N_o and these properties were smaller but significant. Positive relationships between N_o and the amount of clay in soils have been reported previously (Herlihy 1979; Campbell and Souster 1982; Nordmeyer and Richter 1985; Cabrera and Kissel 1988). In the present study, the positive relationship between the total N and clay contents was probably because fine-textured soils commonly

Table 3. Linear coefficients for N-mineralization parameters of 20 meadow soils

Coefficient[z]	N_m	N_e	N_o	h	k_1	Int	k_2	N_ok
N_m	—	0.07	0.84**	−0.34	0.20	0.12	0.98**	0.95**
N_e		—	0.30	−0.24	−0.60**	0.83**	−0.09	−0.12
N_o				−0.49*	0.30	0.20	0.77**	0.68**
h				—	0.49*	−0.48*	0.25	−0.10
k_1					—	−0.41	0.32	0.44*
Int						—	0.04	−0.06
k_2							—	0.98**
N_ok								—

[z] N_m, cumulative amount of N mineralized; N_e, easily mineralizable N; N_o, potentially mineralizable organic N; k_1, rate constant; h, proportionality factor of the Gompertz equation; Int and k_2, intercept and slope of the zero-order equation; N_ok, initial mineralization potential.

*,**Significant at $P < 0.05$ and $P \leq 0.01$, respectively.

Table 4. Linear correlation coefficient between N-mineralization parameters and selected chemical and physical characteristics of 20 meadow soils

Nitrogen-mineralization parameter[z]	Soil characteristic							
	pH	C	S	Cl	N_{tot}	P	K	C:N ratio
N_m	−0.26	0.81**	−0.63**	0.69**	0.86**	−0.28	0.49*	0.02
N_e	−0.12	0.00	0.49*	−0.31	0.05	0.46*	0.45*	−0.12
N_o	−0.21	0.71**	−0.43	0.51*	0.76**	0.00	0.53*	−0.06
h	0.12	−0.20	0.31	−0.38	−0.34	0.00	−0.36	0.40
k_1	0.04	0.10	−0.32	0.25	0.04	−0.51*	−0.29	0.27
b_o	0.04	−0.02	0.25	−0.05	0.06	0.19	0.37	−0.23
k_2	−0.26	0.80**	−0.70	0.73**	0.84**	0.25	0.39	0.04
N_ok	−0.19	0.73**	−0.68	0.72**	0.77**	−0.37	0.30	0.05

[z] N_m, total N mineralized over 55.4 wk; N_e, easily mineralized N over 1.4 wk; N_o, h and k_1, parameters of the Gompertz equation $N_m = N_o e^{-he^{-kt}} - N_o e^{-h}$; b_o and k_2, parameters of the equation $N_m = b_o + k_2 t$.
*,**Significant at $P \le 0.05$ and $P \le 0.01$, respectively.

accumulate more OM than coarse-textured soils because of physical protection through sequestration in soil aggregate matrix and because of chemisorption. The greater initial potential rate of mineralization observed for clay soils is probably also associated with a larger contribution of mineral N from the pool (Nordmeyer and Richter 1985) originating from humic and microbial substrates complexed to clays (Janssen 1984). These clay–humic complexes represent a large pool of N in clay soils. There was no significant relationship between k values calculated from the Gompertz equation and the total amounts of soil C or N (Table 4). The N-mineralization parameters were not correlated with pH values. These results confirm those of Tabatabai and Al-Khafaji (1980), who found no significant relationship between the cumulative N mineralization and the pH values, in the range of 4.6–7.7, of Iowa soils. Dancer et al. (1973) did not observe differences in amounts of N mineralized while raising soil pH to values greater than 5.3. Because none of the soils of the present study had pH values lower than 5.3 (Table 1), the N-mineralization process was therefore not affected by low pH values. Some soil chemical properties were related to N_m, N_o and N_ok, and there was a weak but significant inverse relationship between the rate constant and the amount of available P in the soil ($r = -0.51$*) and a significant positive relationship between the amount of available K and the N_o values ($r = 0.53$*). While direct relationships between P availability have not been clearly established previously (Hadas et al. 1986; Janzen 1987), nine of the soils had available-P values in the low range (Table 1). The results of the present study indicate that low available P was associated with high specific rates of mineralization. The relationship between available K and the N-mineralization potential is not circumstantial, since the amounts of available K and clay contents of these 20 soils are not significantly correlated ($r = 0.16$).

Multiple regression was used to determine whether N_m, N_o, and N_ok could be more precisely predicted from a combination of organic C or N and clay contents (Table 5). The clay content contributed to a significant portion of the variation of N_m predicted when total C was used as first independent variable ($\Delta R^2 = 0.126$**) but not in the case of total N ($\Delta R^2 = 0.041$). The clay content did not contribute a statistically significant portion of the variation in N_o. However, the prediction of N_ok was much improved by the inclusion of the clay content (Table 5). The positive value of the regression coefficient for clay in all these equations indicates that, for given amounts of soil N or C, the amounts of N_m and N_ok will be larger for fine- than for coarse-textured soils.

Table 5. Multiple regression equations developed with various chemical and physical soil properties (X_1 and X_2) to predict N-mineralization parameters (Y)

Y (mg kg^{-1})	X_1 (g kg^{-1})	X_2 (g kg^{-1})	Intercept	b_1[z]	b_2[z]	R^2
N_m	N_{tot}	Clay	39.5	117.1	2.24	0.787
	C_{tot}	Clay	57.1	7.15	3.21**	0.786
N_o	N_{tot}	Clay	65.8	208	1.29	0.518
	C_{tot}	Clay	110.0	12.0	3.22	0.542
N_ok	N_{tot}	Clay	20.0	62.9	2.31	0.698
	C_{tot}	Clay	24.6	4.06	2.74**	0.723

[z]Constant in the regression equation Y (N-mineralization parameter) = $b_o + b_1X_1 + b_2X_2$.
*,**Contribution of the second independent variable is significant at $P \leq 0.05$ and ≤ 0.01, respectively.

CONCLUSION

The cumulative mineralization curves in most soils tested were characterized by definite lags or a sigmoidal pattern and generally linear release with time after 20 wk. Simple first-order or zero-order models inadequately described the data. The growth curves have not been intensively used to describe N-mineralization data in the literature (Ellert and Bettany 1988). In the present study, a very significant linear relationship was found between the initial potential rate of N mineralization, as calculated from the parameters estimated using the Gompertz model, and the total amount of N mineralized. The total amount of mineralized N was closely related to total contents of organic C and N, and the clay content also significantly contributed to the total variation in mineralized N. These results indicate that a long-term N availability is found in clayed soil groups that contain large contents of total C. The N-fertilizer recommendations in use in the area already account for the total amount of C in the determination of N-fertilizer needs of crops in Quebec (SILAC 1991). Field studies should be conducted to investigate if soil texture should be considered as an additional criterion for N-fertilizer recommendations.

The initial potential rate of N mineralization (N_ok) has been proposed as a criterion of soil OM quality (Campbell et al. 1991). The results of the present study indicate that this parameter is very closely related to the total amount of N mineralized and therefore to the N-mineralization potential of a wide range of soils. This parameter is also closely related to the clay content of soils. Classifications of soils of a wide range of textural classes based on the value of N_ok should consider the use of this characteristic.

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