Mineralization of Nitrogen in Organic Soils[1]

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ABSTRACT

The effect of fluctuating seasonal temperatures on the release of soluble NO_3^--N, NH_4^+-N, soluble organic N (SON), and solube organic C (SOC) into drainage effluent during soil organic matter mineralization was measured on organic soil profiles obtained intact from various locations in Florida. Soil columns were leached once every 25 days, followed by applying a suction of 100 cm. Soil columns were flooded for 25 days each in the months of July and August to simulate normal agronomic practices. Leachate was analyzed for NO_3^-, NH_4^+, SON, and SOC.

The amounts of N mineralized ranged from 410 to 938 kg N·ha^{-1}·year^{-1} for cultivated soils and 874 to 1,250 kg·ha^{-1}·year^{-1} for virgin soils. Nitrate accounted for 48 to 81% of the total N in the effluent, while SON accounted for about 16 to 45% of the total N. Remaining 2 to 7% of the total N in the effluent was NH_4^+. Soluble organic C in the leachate accounted for about 1,795 to 3,516 kg C·ha^{-1}·year^{-1}. Seasonal fluctuations in temperatures had minimal effects on the release of SON, SOC, and NH_4^+, but the release of NO_3^- was increased with an increase in average daily temperature (9.4 to 30°C) with Q_{10} values ranging from 1.3 to 1.9. Flooding the organic soils increased the SON and SOC release into the effluents by about two-fold, compared to drained conditions. Total N loss in 1 year as a result of organic matter mineralization was about 1.3 to 4.2% of the total soil organic N.

Additional Index Words: **decomposition, ammonification, nitrification, drainage effluents, soluble organic N, soluble organic C.**

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Organic soils (Histosols) are naturally productive and contain large amounts of organic C, N, and P. These soils are poorly drained and have high water-holding capacities. Artificial drainage is often necessary for agricultural development which results in rapid breakdown of soil organic matter causing soil subsidence (Stephens, 1969). This process also results in the release of various forms of N, as NO_3^-, NH_4^+, and soluble organic N (SON) into drainage water. Drainage water N discharge from organic soils used for agricultrual purposes ranged from 12 to 40 kg N·ha^{-1}·year^{-1} in the Florida Everglades area (Florida Sugar Cane League, 1978) and about 56 kg N·ha^{-1}·year^{-1} in the central Florida area (Reddy et al., 1982). Other studies reported a drainage water N discharge of about 37 to 245 kg N·ha^{-1}·year^{-1} for organic soils located in New York (Duxbury and Peverly, 1978).

The biochemical processes controlling N release into drainage water include ammonification, nitrification, and dentrification. These processes along with soil and environmental factors (moisture and temperature) dictate the amount of N released into drainage water. A few studies have been reported on N mineralization in organic soils (Avnimelech, 1971; Isirimah and Keeney, 1973; Guthrie and Duxbury, 1978; Terry, 1980). Mineralization rates (360 to 686 kg N·ha^{-1}·year^{-1}) in these studies were based on either batch or short-term incubation at constant temperature. None of the studies reported account for the effect of temperature fluctuations and management practices (summer flooding) on mineralization of soil organic N.

The purpose of this investigation was to measure the effect of fluctuating seasonal temperatures and flooding on the release of NO_3^-, NH_4^+, SON, and SOC into drainage water during soil organic matter decomposition. Natural soil profiles collected from various locations in Florida were used in the study.

MATERIALS AND METHODS

Soils

Intact soil columns from seven locations across Florida (Table 1) were obtained by slowly driving a polyvinyl chloride (PVC) pipe (7.5 cm i.d.) to a depth of about 70 cm. This method has resulted in very little or no change in soil bulk density. Soil columns were obtained at random from five areas used for growing vegetable crops and from two virgin areas. Three soil columns were obtained at each location. Five sampling locations (one virgin and four cultivated) were in central Florida while two (one virgin and one cultivated) were obtained from south Florida. Organic soils of south Florida are associated with Lake Okeechobee, while organic soils of central Florida are associated with Apopka, Yale, or Griffin lakes. At the sample sites, soils (three replications) were also obtained at depth increments of 0-30, 30-60, and 60-90 cm to determine selected characteristics as shown in Table 2. Soil columns were sealed with PVC caps and stored at 4°C until experimental analysis. Maximum storage period was 3 weeks for south Florida soils and 2 weeks for central Florida soils.

Incubation Procedures

The bottom portion of the column was sealed to a porus plate and glued to a PVC cup (Fig. 1) provided with an outlet. Glass wool and a thin layer of prewashed sand were placed on top of the soil column. Each soil column was leached with 2 liters of 0.01*M* $CaCl_2$ followed by 1 liter of distilled water to remove initial NO_3^-, NH_4^+, SON, and SOC from the soil. Soil columns were allowed to drain naturally followed by applying 100 cm (H_2O) suction to maintain soil moisture at optimum level for organic matter decomposition (Terry, 1980). Leachate obtained at the start of the incubation was analyzed for NH_4^+, NO_3^-, and organic N (Table 3). Initial NH_4^+, NO_3^-, SON, and SOC leached at zero time were not used in estimating the mineralization potential of organic soils. Soil columns were then incubated in a greenhouse shaded with wooden lattice. Outside air was continuously blown into the greenhouse by cross ventilation and an electric fan. This was done in order to keep the temperature in the greenhouse the same as the outside temperature. Incubation was initiated on 11 Apr. 1980 for central Florida soils and 16 May 1980 for south Florida soils.

Soil columns were leached once every 25 days for a period of 53 weeks with 1 liter (3 cm/hour) of distilled water and were allowed to drain naturally followed by a 100-cm suction. During July, soil columns were flooded to a depth of 5 cm for a period of 25 days, followed by leaching, as

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Table 1—Description of the soils used in leaching studies.

Soil symbol	Soil series	New classification	Location	Associated lakes
		Cultivated soils		
F	Oklawaha muck	Terric Medifibrists Clayey, mixed, Euic, hyperthermic	Eustis-Leesburg	Lake Yale-Lake Griffin
D	Monteverde muck	Typic Medifibrists, Euic, hyperthermic	Zellwood	Lake Apopka
C	Lauderhill muck	Lithic Medisaprists Euic, hyperthermic	Zellwood	Lake Apopka
A	Brighton muck	Typic Medifibrists, Dysic	Zellwood	Lake Apopka
BC	Pahokee muck	Lithic Medisaprists Euic, hyperthermic	Belle Glade	Lake Okeechobee
		Virgin soils		
EV	Monteverde muck	Typic Medifibrists Euic, hyperthermic	Zellwood	Lake Apopka
BV	Pahokee muck	Typic Medisaprists Euic, hyperthermic	Belle Glade	Lake Okeechobee

described above. In Florida, organic soils used for agricultural purposes are flooded during summer months (July thorugh August) to control weeds and soil-borne pests and to reduce soil subsidence. Soil columns wre flooded again in August for an additional period of 25 days, followed by draining and a 100-cm suction. After every leaching, the volume of leachate (drainage effluent) was measured and analyzed for NO_3^-, NH_4^+, SON, and SOC. Temperature in the greenhouse was continuously monitored (Fig. 2) using a recording thermograph.

Analytical Methods

Soil pH was determined on a 2:1 water/soil mixture by glass electrode. Additional intact soil columns (three per location) obtained from the same locations were sectioned into 30-cm-depth increments to determine bulk density. Total carbon was estimated by wet oxidation method (Allison, 1965) and total N by Kjeldahl digestion and steam distillation (Bremner, 1965a). Ammonium and nitrate in the soils were extracted with 2*M* KCl solution and analyzed by

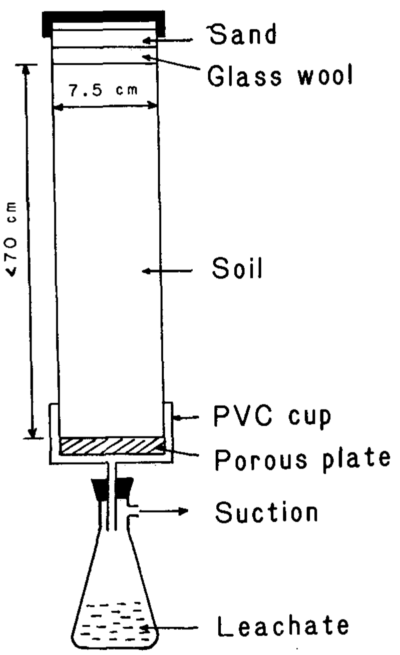

Fig. 1—Schematic presentation of the experimental setup used in leaching experiments.

Table 2—Selected characteristics of the soils used in the study.

Soil symbol	Depth	Bulk density	pH	Total N	Total C	C/N ratio	Water content at 100 cm suction
	cm	g/cm³		%	%		cm³/cm³
			Cultivated soils				
F	0-30	0.31	5.7	2.11	36.7	17.4	0.65
	30-60	0.20	5.7	2.01	35.7	17.8	0.83
	60-90	0.16	5.5	1.87	36.5	19.5	0.79
D	0-30	0.33	6.5	2.52	36.6	14.5	0.59
	30-60	0.34	6.4	2.80	37.2	13.3	0.71
	60-90	0.12	6.0	2.90	35.4	12.2	0.80
C	0-15	0.32	6.4	3.68	43.5	11.8	0.57
	15-30	0.32	6.5	3.80	42.1	11.1	0.52
	30-40	0.92	6.9	0.78	6.7	8.6	0.15
A	0-30	0.33	5.9	3.15	38.5	12.2	0.53
	30-60	0.12	4.8	3.18	37.2	11.7	0.79
	60-90	0.13	4.9	3.34	36.4	10.9	0.81
BC	0-30	0.36	6.3	3.81	46.9	12.3	0.52
	30-60	0.18	6.1	3.45	42.1	12.2	0.74
			Virgin soils				
EV	0-30	0.14	5.5	2.40	36.4	15.2	0.63
	30-60	0.12	6.3	2.73	36.5	13.4	0.75
	60-90	0.48	7.4	0.45	7.4	16.4	0.30
BV	0-30	0.34	5.4	3.59	44.0	12.3	0.56
	30-60	0.16	4.9	3.01	42.5	14.1	0.84

steam distillation method (Bremner, 1965b). Soil samples were also extracted with water (soil/water ratio = 1:5) and filtered through a 0.3 μm glass fiber filter after 30 min of shaking. Filtered solutions were analyzed for SON by micro-Kjeldahl digestion and steam distillation (Bremner, 1965a) and SOC by auto analyzer. The method used to quantify soluble organic C involves the oxidation of organic C by ultraviolet radiation in the presence of acid and potassium persulfate. The resultant CO_2 generated from organic C is dialyzed through a silicone rubber membrane and reacted with weakly buffered phenolphthalein indicator. Decrease in color of the indicator is proportional to the C concentration of the samples (Goulden and Brooksban, 1975; Technicon, 1978). Ammonium NO_3^-, SON, and SOC in the drainage water (leachate) were analyzed as described above.

RESULTS AND DISCUSSION

Ammonium Nitrogen

Ammonium release into drainage water under aerated conditions was < 0.4 μg N/cm³ of soil per leaching period for all organic soils throughout the entire incubation (Fig. 3). Low NH_4^+ levels in the effluent indicates rapid nitrification of the mineralized NH_4^+. Nitrification was shown to occur at a rapid rate in well-aerated organic soils (Tate, 1977) which has resulted in very little or no NH_4^+ accumulation under

Table 3—Soluble N and C in the soil columns at the start of the experiment.

Soil symbol	NO_3^--N	NH_4^+-N	SON	SOC
	μg/cm³ of soil			
		Cultivated soils		
F	3.54	1.07	2.43	36.0
D	17.80	0.13	2.39	21.5
C	51.68	0.13	5.78	39.6
A	25.48	0.01	2.12	28.0
BC	61.49	0.22	3.29	39.1
		Virgin soils		
EV	5.27	0.15	2.39	23.5
BV	38.69	0.49	5.22	64.3

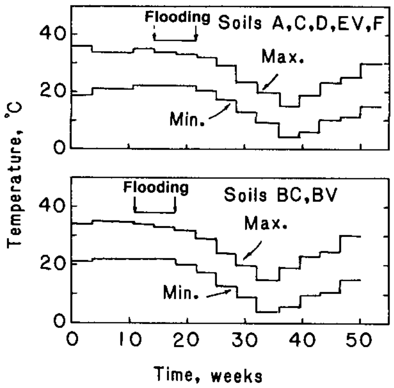

Fig. 2—Maximum and minimum incubation temperature (°C) during 53 weeks. Starting incubation for soils A, C, D, EV, and F was 11 Apr. 1980 and 16 May 1980 for soils BC and BV, respectively. A = Brighton; C = Lauderhill; D = Monteverde; EV = Monteverde (virgin); F = Oklawaha; BC = Pahokee; BV = Pahokee (virgin).

aerated conditions. Flooding the organic soils during July and August increased the accumulation of NH_4^+ in the soil profile. Ammonium leached at the end of the flooding period was in the range of 1.64 to 3.85 μg N/cm^3 of soil. Ammonium leached under flooded conditions accounts only for the water-soluble fraction and does not account for the exchangeable fraction. Ratio between exchangeable and water-soluble NH_4^+ fractions in flooded organic soils was found to be between one and two (Reddy, 1981, unpublished results). Thus the NH_4^+ released into effluent represents only one-quarter to one-half of the total NH_4^+ produced in the soil profile.

Total NH_4^+ released into effluents during a one-year-study period was in the range of 19 to 30 kg N·ha^{-1}·year^{-1} for all the soils studied. About 40 to 70% of the total NH_4^+ released came during the two 25-day-flooding periods in July and August. No significant difference was observed between cultivated and virgin soils. Ammonium accounts for only 2.2 to 7.3% of the total N leached into drainage effluent while the remaining N was either in NO_3^- or organic N forms (Table 3.).

Nitrate Nitrogen

Average amounts of NO_3^- leached from the soil columns maintained under aerated conditions were in the range of 0.7 to 32.3 μg N/cm^3 of soil per leaching period over a one-year-study period (Fig. 4). Amounts of NO_3^- leached were variable among the soils studied. Apparent mineralization ranged from 32 to 161 μg N/cm^3 of soil over a 53-week period for soils of central Florida and 117 to 145 μg N/cm^3 of soil over a 50-week period for soils of south Florida. For soils of central Florida, mineralization rates were about the same for two cultivated soils (A and D) and a virgin soil (EV). Although soil C had a shallow organic soil profile (about 35 cm), mineralization rate was significantly higher than other central Florida soils. Soil C was obtained from an experimental farm, immediately after the incorporation of residues from a previous sweet corn crop. Enhanced mineralization in this soil was probably due to the decomposition of crop residues (Terry, 1980), whereas cultivated soils A and

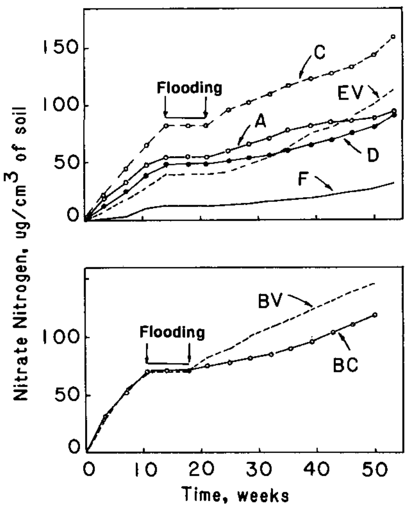

Fig. 3—Cumulative NH_4^+-N release into drainage effluent from several organic soils during 53 weeks. A = Brighton; C = Lauderhill; D = Monteverde; EV = Monteverde (virgin); F = Oklawaha; BC = Pahokee; BV = Pahokee (virgin).

D were obtained several days after the incorporation of crop residues. Mineralization rate in soil F was very low (32 μg N/cm^3 of soil per 375 days). This soil was uncropped at the time of sampling, and soil water content of the profile was close to saturated conditions. Mineralization rates were significantly higher in soils BC and BV than central Florida soils with the exception of soil C.

Cumulative N mineralization rate (curves) as shown in Fig. 4 are curvilinear for all soils. By ignoring the flooding period, correlation coefficients for linear regression of cumulative N mineralization on the square root of the incubation time generally showed highly significant R^2 values (> 0.98). Unlike mineral soils, organic soils mineralize N at a steadier rate, hence a constant fraction of total N is always potentially mineralizable. Laboratory batch incubation studies on organic soils conducted by Terry (1980) at a constant temperature showed a linear mineralization rate.

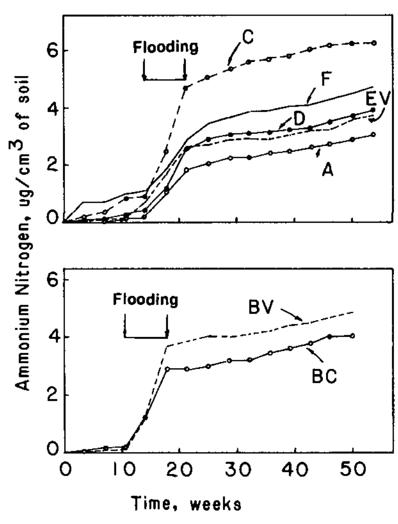

Fig. 4—Cumulative NO_3^--N release into drainage effluent from several organic soils during 53 weeks. A = Brighton; C = Lauderhill; D = Monteverde; EV = Monteverde (virgin); F = Oklawaha; BC = Pahokee; BV = Pahokee (virgin) .

Table 4—Potential N and C loss into drainage effluents from several organic soils.

Soil symbol	NO_3^--N	NH_4^+-N	SON	Total N	SOC
	kg N/ha-yr				
	Cultivated soils				
F	196 (47.8)†	30 (7.3)	184 (44.9)	410	1,795
D	556 (76.4)	24 (3.3)	148 (20.3)	728	1,135
C	533 (72.0)	23 (3.1)	184 (24.9)	740	1,309
A	589 (71.1)	19 (2.3)	220 (26.6)	828	2,288
BC	679 (72.4)	23 (2.5)	236 (25.1)	938	2,498
	Virgin soils				
EV	711 (81.4)	20 (2.3)	143 (16.3)	874	1,478
BV	839 (67.1)	28 (2.2)	383 (30.7)	1,250	3,516
L.S.D. (0.05)	125	9	41		350

† Values in the parentheses are the percent of the total N in the effluents.

Curvilinearity of the data shown in Fig. 4 was probably due to the effects of temperature fluctuations and flooding in summer months.

The data in Fig. 4 also show that flooding the organic soils during July and August affected NO_3^- production during subsequent months (September and October) where incubation was under drained conditions. This was probably due to the accumulation of organic acids and lag phase in the buildup of aerobic microbial populations, particularly nitrifying organisms.

The quantities of NO_3^- leached into the effluent correspond to about 196 to 711 kg N·ha^{-1}·year^{-1} for central Florida organic soils and 679 to 839 kg N·ha^{-1}·year^{-1} for south Florida organic soils (Table 4). It should be noted that these extrapolation are based on about 86% of the incubation period under aerated conditions and with about 14% of the incubation time under flooded conditions (during July and August). The amounts of NO_3^- leached from cultivated organic soils ranged from 196 to 679 kg N·ha^{-1}·year^{-1} and 711 to 839 kg N·ha^{-1}·year^{-1} for virgin soils, respectively. Nitrate that was leached into drainage effluent accounted for about 48 to 81% of the total N in the effluent, while remaining N was either in organic or NH_4^+ fractions. If these soils were incubated continuously under aerated conditions (without summer flooding), NO_3^- formation rates would be significantly higher than those reported above.

Soluble Organic Nitrogen (SON)

Cumulative amounts of SON leached into effluents was shown to be linear (R^2 = < 0.96) with respect to incubation time (Fig. 5). Soluble organic N released into effluent was in the range of 0.066 to 0.162 μg·cm^{-3}·day^{-1} for cultivated soils and 0.069 to 0.20 μg·cm^{-3}·day^{-1} for virgin soils. On an annual basis (includes the effect of flooding in July through August), SON release into leachate was 148 to 236 kg N·ha^{-1}·year^{-1} for cultivated organic soils and 160 to 463 kg N·ha^{-1}· year for virgin organic soils, respectively. Organic soils of central Florida have a potential SON release capacity of 143 to 220 kg N·ha^{-1}·year, compared to 236 to 383 kg N·ha^{-1}·year^{-1} for south Florida soils. Soluble organic N fraction is the most important component of total N and is usually considered to be available for microbial oxidation to NH_4^+ and subsequently to NO_3^-. The sequential processes that function in the conversion of soil organic N to NO_3^- include: soil organic N → water-soluble organic N → ammonification → nitrification. If mineralization studies are conducted using leaching techniques, measuring NO_3^- in the leachate can underestimate the net mineralization potential of soils (Smith et al., 1980). For example, in this study SON accounted for 16.3 to 44.9% of the total N leached into the effluent for various organic soils (Table 4). If this SON were retained in the soil profile, the microorganisms probably would have converted SON to NO_3^-. On the other hand, batch incubation procedures to measure net mineralization do not represent field conditions but will retain SON for subsequent breakdown by microorganisms.

Soluble Organic Carbon (SOC)

Soluble organic C release into drainage water followed similar trends as SON (Fig. 6). Soluble organic C released into the effluent was in the range of 0.47 to 1.13 μg·cm^3·day^{-1} for cultivated soils and 0.62 to

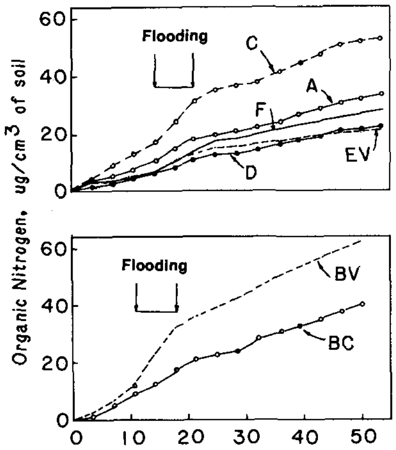

Fig. 5—Cumulative SON release into drainage effluent from several organic soils during 53 weeks. A = Brighton; C = Lauderhill; D = Monteverde; EV = Monteverde (virgin); F = Oklawah; BC = Pahokee; BV = Pahokee (virgin).

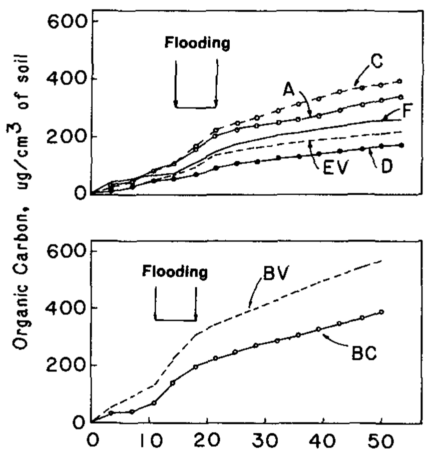

Fig. 6—Cumulative SOC release into drainage effluent from several organic soils during 53 weeks. A = Brighton; C = Lauderhill; D = Monteverde; EV = Monteverde (virgin); F = Oklawaha; BC = Pahokee; BV = Pahokee (virgin).

1.60 $\mu g \cdot cm^3 \cdot day^{-1}$ for virgin soils. Organic soils of south Florida released about 2,498 to 3,516 kg C·ha^{-1}·year^{-1} compared to 1,135 to 2,288 kg C·ha^{-1}·year^{-1} released by the organic soils of central Florida.

Significant relationship (R^2 = 0.86**) was observed between SOC and SON of the effluent with an average C/N ratio of 10.2 ± 5.2 for cultivated organic soils and 11.2 ± 6.4 for virgin organic soils. Carbon–nitrogen ratios of the soil profile were also in the same order of magnitude. It was anticipated that C/N ratios of the effluent would be smaller than the soils if the SOC and SON are contributed by microbial biomass.

Effect of Temperature Fluctuations

Seasonal temperature fluctuations had minimal effects on the release of NH_4^+, SON, and SOC into the drainage effluent. However, NO_3^-, the end product of aerobic mineralization sequence, was influenced by the temperature. Average daily ambient air temperature was calculated using the equation shown below and correlated with the mineralization rates (Fig. 7):

$$\text{average daily ambient air temperature} = \Sigma\,(T_{max} + T_{min})/2t,$$

where T_{max} = maximum daily air temperature (°C); T_{min} = minimum daily air temperature (°C); and t = incubation days between each leaching.

A significant relationship was observed between mineralization rates and average daily ambient air temperature (9.4 to 28.5°C). For cultivated soils (A, C, D, and BV), a significant relationship was observed between mineralization rates and temperature (R = 0.86**) with Q_{10} values of 1.9. Virgin soils EV and BV also showed significant relationships (R = 0.76**) with Q_{10} values of 1.5. However, cultivated soil F, which had low mineralization rates, showed poor relationship with air temperature (R = 0.46 NS) and a Q_{10} value of 1.4. Although Q_{10} values were computed based on average daily ambient air temperatures, the results are in agreement with the values measured in experiments conducted at constant temperatures (Stanford et al., 1973; Reddy et al., 1979).

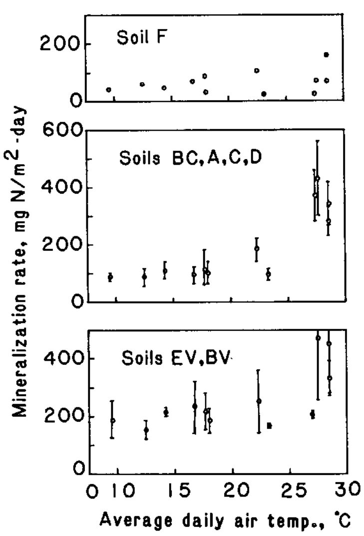

Fig. 7—Effect of temperature on rate of mineralization in organic soils. A = Brighton; C = Lauderhill; D = Monteverde; EV = Monteverde (virgin); F = Oklawaha; BC = Pahokee; BV = Pahokee (virgin).

Flooded vs. Drained Conditions

Flooding the organic soils significantly increased SON and SOC released into drainage effluents compared to drained conditions (Table 5). Under flooded conditions SON release was in the range of 212 to 369 kg N·ha^{-1}·year^{-1} for cultivated soils and 339 to 849 kg N·ha^{-1}·year^{-1} for virgin soils, respectively. Under drained conditions SON release was significantly lower, with about 167 to 293 kg N·ha^{-1}·year^{-1} for cultivated soils, and 201 to 383 kg N·ha^{-1}·year^{-1} for virgin soils, respectively. Organic soils of central Florida released less SON, compared to the soils in south Florida, under both flooded and drained conditions. Similar trends were also observed for SOC release into the effluents. Soluble organic C release approximately doubled under flooded conditions, compared to drained conditions.

Effect of Mineralization on N Loss

Total amount of N leached from the soil profile as a result of solubilization of organic matter and subsequent breakdown into inorganic N was in the range of 1.3 to 4.2% of the total soil N. Virgin soils lost more N (2.6 to 4.2% of the total soil N) than cultivated soils (1.3 to 1.9% of the total soil N). This accounts for an annual subsidence rate of 0.7 to 2.7 cm/year as a result of microbial oxidation. Stephens (1969) observed a subsidence rate of 3 cm/year for Florida organic soils. Under field conditions, cultivated soils which are artifically drained several times during the year subside faster than virgin soils, which drain slowly under natural conditions and remain anaerobic for longer periods.

Agronomic and Environmental Significance

Agronomically, more N is mineralized in organic soils than the crop needs. In Florida, it has been estimated that vegetable crops (2 to 3 crops per year) remove about 300 to 400 kg N/ha (K. R. Reddy and J. M. White, 1981, unpublished results, Univ. of Florida), while a crop of sugar cane would remove about 80 to 100 kg N/ha (Barnes, 1974). These soils are naturally poorly drained, and artificial drainage is often necessary to keep the water table at an optimum level. This is accomplished by mole drains established at about the 90-cm depth. During heavy rainfall excess water is drained into adjacent small canals, which flows into larger canals. Water from larger canals is pumped into retention reservoirs or into adjacent lakes. Although the amount of N mineralized in the field is high (410 to 1,250 kg N·ha^{-1}·year^{-1}), actual amounts of N discharged into adjacent water bodies is about 12 to 56 kg N·ha^{-1}·year^{-1} (Florida Sugar Cane League, 1978; Reddy et al., 1982). This suggests that both organic soil fields and the adjacent canals are functioning as sinks for N removal probably through denitrification (Reddy et al., 1980) and uptake by aquatic macrophytes. Organic soils which are not used for cultivation (virgin soils) pose little threat with respect to discharge of N into drainage water because

Table 5—Soluble organic C and soluble organic N release into drainage effluent, as influenced by flooded and drained conditions, over a period of two 25-day incubations.†

	SON				SOC			
Soil symbol	Flooded	Drained	Flooded	Drained	Flooded	Drained	Flooded	Drained
	mg N/column		kg/ha		mg N/column		kg/ha	
				Cultivated soils				
F	24.5	10.9	55.5	24.7	220	59	498	134
D	12.8	10.1	29.0	22.9	106	81	240	183
C	20.2	13.0	45.7	29.4	174	84	394	190
A	20.6	16.6	46.6	37.6	267	169	604	383
BC	21.8	17.7	49.3	40.1	299	155	677	351
				Virgin soils				
EV	20.5	12.2	46.4	27.6	225	89	509	201
BV	51.4	23.2	116.3	52.5	426	187	964	423
L.S.D. (0.05)	6.2		12.5		25.1		171.5	

† Average incubation temperature for drained condition was 28.5 and 27.9°C for flooded conditions.

these soils are not drained artificially, and the potential exists for maximum N removal through denitrification.

In conclusion, extrapolating the soil columns' data to field conditions indicate that about 410 to 1,250 kg $N \cdot ha^{-1} \cdot year^{-1}$ can be leached into drainage water. Nitrate accounted for about 48 to 81% of the total N in the effluent. Net mineralization rates were found to be significantly correlated with ambient daily air temperatures. Flooding the organic soils approximately doubled the release of SON and SOC into effluents compared to drained conditions.

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On p. 563, the illustrations for Fig. 3 and Fig. 4 were reversed; i.e., the illustration shown as Fig. 3 should be Fig. 4; and that shown as Fig. 4 should be Fig. 3.