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Inhibition of Nitrification in Soils Treated with Pig Slurry

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It is widely recognised that rapid nitrification in soils can result in decreased efficiency of use of fertilizer N and contribute to the nitrate content of groundwaters. The undesirable consequences of the process have been fully reviewed by HAUCK (1972) and PARR (1973).

Chemical inhibitors of ammonia-oxidising bacteria have been used successfully to control nitrification rates in soils treated with ammonium salts and urea (GORING 1962 a, b; TURNER et al 1962; BUNDY and BREMNER 1973) without affecting other microbial processes and when used in conjunction with ammoniacal fertilizers on grassland soils they can decrease the nitrate content of herbage and make possible the application of fertilizer outside the crop growing season without the risk of losses through leaching and denitrification (ASHWORTH et al 1977; TURNER and MacGREGOR 1978).

Benefits such as these would be desirable in pasture soils receiving frequent applications of animal slurries since these wastes are capable of promoting rapid nitrification through transient elevation of soil pH (COOPER 1975). The aim of the work reported here was to determine the effectiveness of three compounds in controlling nitrification rates in a range of soils treated with pig slurry.

MATERIALS AND METHODS

Inhibitors were chosen on the basis of results obtained by BUNDY and BREMNER (1973) who tested fourteen compounds for their effectiveness in controlling nitrification of ammonium sulphate and urea. The three most effective inhibitors chosen for the present study were: 2-chloro-6-(trichloromethyl)-pyridine (N-Serve, Dow Chemical Co., Midland, Michigan, U.S.A.), 4-amino-1, 2, 4-triazole (ATC, Ishahara Industries, Japan) and sodium azide.

Soils were chosen for their different pH values and physical properties and were air dried and passed through a 2 mm screen before use. The main chemical and physical properties of the soils are presented in Table 1.

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TABLE 1

Properties of soils

Soil	pH[1]	CEC[2]	Organic carbon	Total nitrogen	Coarse sand	Fine sand	Silt	Clay
			%					
A	5.7	34	2.06	0.238	31.9	26.0	25.3	16.8
B	6.3	36	1.99	0.273	14.9	23.7	53.7	7.7
C	6.8	34	1.80	0.259	26.7	22.8	39.1	19.5

[1] glass electrode, 1:4 suspension of soil in deionised water.

[2] cation exchange capacity (meq/100 g soil).

Soil incubations were employed to study the effects of the inhibitors and the experimental details were as follows: pig slurry, collected from a tank receiving the waste flow from an intensive rearing unit, was diluted three fold with water and split into lots to receive different quantities of stock solutions of the three inhibitors. Three ml amounts of slurry/inhibitor solution were added to 8 g samples of soils spread thinly on the flat sides of 125 ml medicine bottles. Sufficient deionised water was added to bring the samples almost to field capacity. The concentration of slurry NH_4^+-N in each sample was approximately 300 μg/g dry soil and the final concentrations of each inhibitor were 0, 5, 10 and 20 μg/g dry soil. Enough bottles were prepared to allow destructive sampling of duplicates for each treatment, weekly for 4 weeks. Bottles, with loosely fitted plastic caps, were incubated at 25°C and 95% relative humidity. To determine mineral nitrogen content, samples were shaken for 1 h in a 1:10 soil, 2NKCℓ suspension followed by filtration through Whatman No. 42 paper. Filtrates were analysed for NH_4^+-, NO_2^-- and NO_3^--N using the MgO-Devarda alloy method of BREMNER and KEENEY (1965). The effectiveness of each compound was assessed by the method described by BUNDY and BREMNER (1973) using the formula (C - S)/C x 100 where S = amount of (NO_2^-- + NO_3^--)N produced in a soil sample treated with the test compound and C = amount of (NO_2^-- + NO_3^--)N produced in the control (no inhibitor added).

RESULTS AND DISCUSSION

Nitrification patterns in the three slurry-treated soils, in the absence of inhibitors, are presented in Fig. 1. The amounts of NH_4^+-N oxidised to NO_3^--N were positively correlated with initial soil pH values and in soil C almost all NH_4^+-N was nitrified in four weeks. Negligible quantities of NO_2^--N were detected during the experiment.

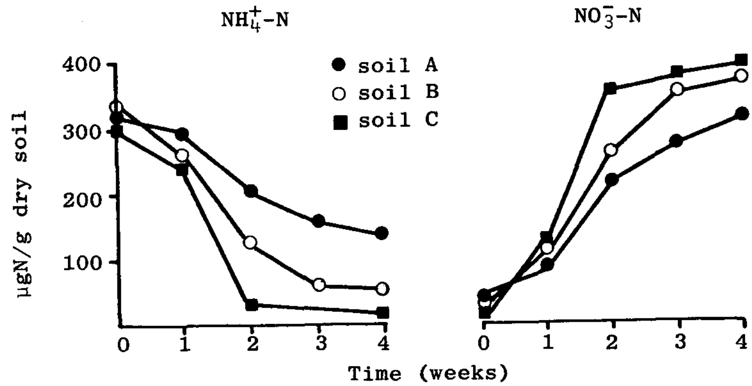

Fig. 1. Nitrification patterns in three soils receiving pig slurry and no inhibitors.

Percentage inhibition values for all combinations of inhibitor concentrations and soils are presented in Fig. 2. Values are given for weeks 2, 3 and 4 of the experiment since it was apparent from the controls that the nitrifying potential of the soils was at its maximum from the second week of incubation.

N-Serve and ATC were clearly more effective than sodium azide in all soils at all concentrations. Only at the highest application rate did sodium azide provide substantial inhibition. Furthermore, this was of limited duration with the inhibition value, meaned over the three soils, falling from 88% in week 2 to 36% in week 4.

N-Serve and ATC were similarly effective in all soils at application rates of 10 and 20 µg/g but at the lowest rate N-Serve was more persistent than ATC in soils B and C, with significantly higher percentage inhibition values in the fourth week of incubation. With this exception there was little difference in the performance of each inhibitor in the three soils. BUNDY and BREMNER (1973) reported that many nitrification inhibitors were more effective in light-textured sandy soils than in those with a clay content higher than 30%. Although there were marked physical differences between the soils in the present study, all had clay contents lower than 20%.

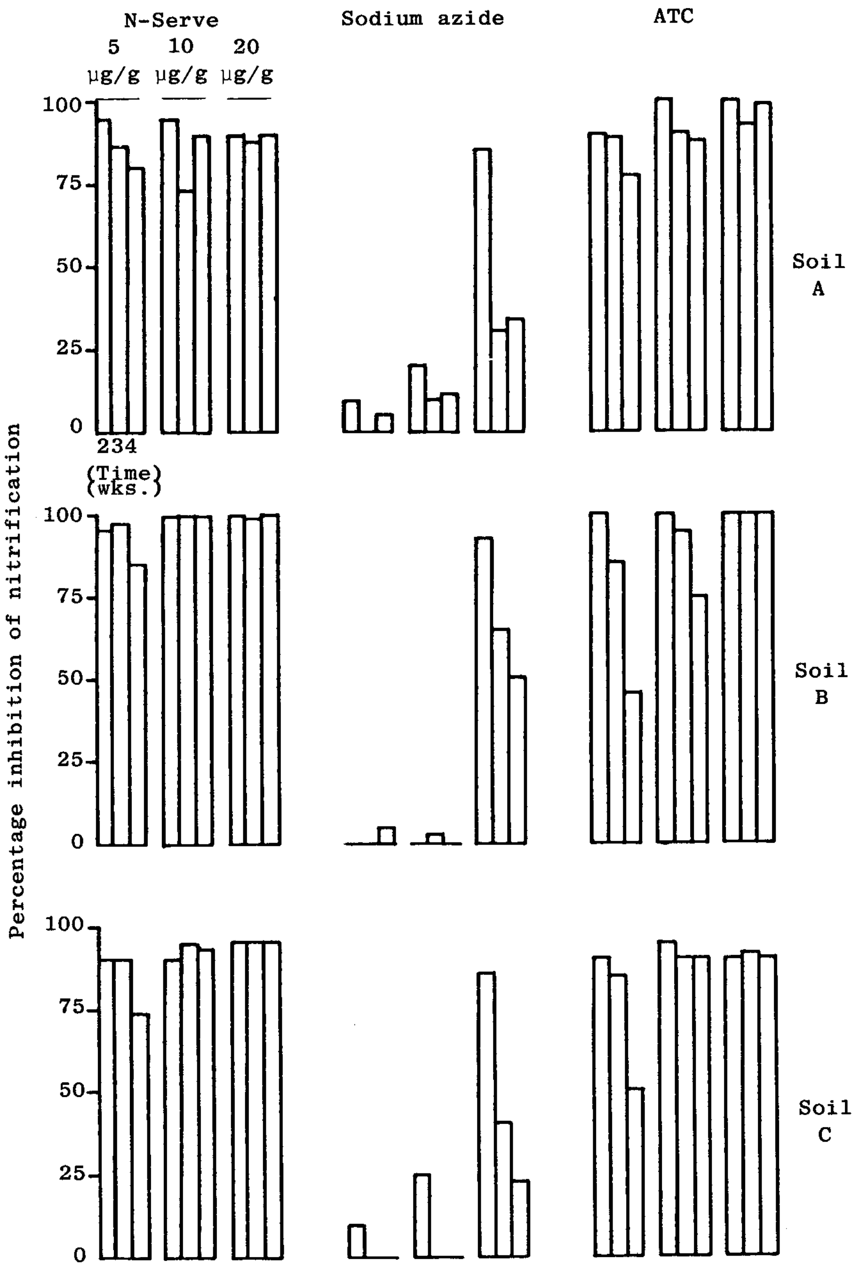

Fig. 2. Percentage inhibition of nitrification in three soils incubated with pig slurry and various inhibitors.

It is not possible to predict suitable field application rates for inhibitors from experiments in closed systems, but the requirement for higher rates to compensate for movement through soil may, to some extent, be offset by the increased persistance of compounds at lower soil temperatures (HERLIHY and QUIRKE 1975). In conclusion, N-Serve and ATC were effective inhibitors of the oxidation of slurry NH_4^+-N in all three soils, but sodium azide was ineffective, even for short periods, at all but unrealistically high concentrations.

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