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Short Communication

INHIBITORY EFFECTS OF COMMERCIAL POTASSIUM CHLORIDE ON THE NITRIFICATION RATES OF ADDED AMMONIUM SULPHATE IN AN ACID RED YELLOW PODZOLIC SOIL†

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KEY WORDS

Ammonium chloride Ammonium sulphate Chloride effect Low pH soils Nitrification inhibition.

SUMMARY

Rates of nitrification of ammonium sulphate in an acid red yellow podzolic tea soil in Sri Lanka with and without the addition of commercial potassium chloride (95% KCl) and analytical grade KCl was studied under field conditions and in a laboratory incubation experiment. Addition of KCl effectively suppressed nitrification and this suppression was found to be due to the presence of Cl-ions rather than K-ions.

INTRODUCTION

A large fraction of the nitrogen requirements of the tea (*Camellia sinensis* L.) plantations in Sri Lanka is supplied in the form of sulphate of ammonia. High nitrogen rates prevailing in tea soils could lead to a considerable loss of N from the root zone of the tea crop. Also the possibility of denitrification losses increases with large NO_3-N concentration resulting from rapid nitrification. Therefore many attempts have been made to reduce the nitrification rate. A number of substances are known to inhibit nitrification though none could be used effectively on large scale under field conditions. The possibility of reducing the rate of nitrification by a proper combination of fertilizer was suggested by Hahn *et al*[2]. This investigation was therefore undertaken to study the effect of addition of commercial potassium chloride ('muriate of potash' containing 95% KCl) in the field or analytical grade KCl under laboratory conditions on the nitrification rate of added ammonium sulphate.

EXPERIMENTAL

(1) Field experiment

The plots used to study nitrification under field conditions were from a field experiment designed in 1961 to study the effect on yield of 3 levels of N (applied as ammonium sulphate) 3 levels of P (applied as rock phosphate) and 3 levels of K (applied as commercial potassium chloride) in all combinations.

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The soil in the experimental site belongs to the Red-yellow podzolic great soil group and Coombe series.[1] Plots with the following NK treatments at the highest level of P (49 kg P/ha/year) were selected.

N_1K_0 - 112 kg N/ha/year without K
N_2K_0 - 224 kg N/ha/year without K
N_3K_0 - 336 kg N/ha/year without K
N_1K_2 - 112 kg N/ha/year with 116 kg K/ha/year
N_2K_2 - 224 kg N/ha/year with 116 kg K/ha/year
N_3K_2 - 336 kg N/ha/year with 116 kg K/ha/year
N_0K_0 - Control without any fertilizer

Since the fertilizer had been given in four equal doses the plots had received one fourth the quantity indicated. Rates of nitrification were studied by sampling the soil solution in duplicate at 20 cm depth using suction soil solution samplers[8], at weekly intervals after a surface application of fertilizer.

INCUBATION EXPERIMENT

Soil from 0-20 cm depth of the N_1K_0 plot was sampled using a core sampler and passed through a 2 mm sieve. After partially drying in air, 250 g samples of soil at 25% moisture (w/w) were separately mixed in triplicate with solutions containing the analytical grade reagents (Table 1) in such a way to make up the final moisture content equivalent to 90% field capacity. The samples were stored in loosely tied polythene bags and adjusted for any evaporation losses at 4-day intervals.

Each of the treatments (Table 1) were imposed on three soil samples and incubated separately at room temperature (22±1°C). One sample (10 g) was drawn from each bag at weekly intervals and analysed separately for 2 N-KCl extractable NO_3-N by phenol disulphonic acid method and for NH_4-N by the indophenol blue method. The mean concentration of NO_3^- nitrogen calculated from the three values was taken to represent the treatment effect.

RESULTS AND DISCUSSION

Field experiments

Nitrification of added ammonium sulphate as indicated by soil solution nitrate concentration, gave rise to large quantitites of NO_3-N in all K_0 treatments (Table 2). Peak concentrations of NO_3-N observed in N_1K_0 N_2K_0 and N_3K_0 were 43, 110 and 160 ppm respectively. In the plots which received potassium chloride (K_2 treatment) the NO_3-N concentration never exceeded 30 ppm irrespective of N levels. There was only negligible NO_3-N in the soil that did not receive any fertilizer (3 ppm.)

TABLE 1 — *Treatments in the laboratory experiment and the concentration of various ions in the treatments*

Treat No.	*N-source*	*N (ppm)*	*K (ppm)*	*Cl (ppm)*
(1) Control	—	0	0	0
(2)	$(NH_4)_2SO_4$	75	0	0
(3)	$(NH_4)_2SO_4$	75	50	46
(4)	$(NH_4)_2SO_4$	75	100	91
(5)	$(NH_4)_2SO_4$	75	300	273
(6)	NH_4Cl	75	0	190

TABLE 2 — *Concentration of NO_3-N (ppm) in soil solution at 20 cm depth in the treated plots*

Treatment.	*Concentration of NO_3-N (ppm) after days*								
N_1K_0	10	15.7	42.6	40.9	32.6	27.3	22.3	17.8	11.1
N_2K_0	27.3	30.6	32.3	55.8	74.4	98.2	112.7	112.4	103.6
N_3K_0	17.3	24.3	59.6	70.7	111.6	120.0	150.9	160.0	141.8
N_1K_2	7.3	14.5	30.6	26.0	32.6	21.4	17.7	9.5	11.4
N_2K_2	5.0	5.3	12.3	12.1	11.6	7.7	7.1	5.4	1.8
N_3K_2	13.7	11.5	18.7	22.8	18.6	15.0	14.1	14.3	11.8
Control	0.5	0.8	0.9	0.5	2.8	1.4	1.6	2.2	1.1

The amounts of KCl extractable NH_4-N in the 0-20 cm soil depth, 59 days after fertilizer application in the different treatments are shown in Table 3. In the presence of KCl at both N_2 and N_3 levels large amounts of NH_4-N remained without undergoing any nitrification showing inhibition of nitrification by commercial potassium chloride.

Maximum KCl extractable NH_4-N was 167 ppm in the N_3K_2 treatment. In the presence of potassium chloride, in both N_2 and N_3 levels large amounts of NH_4-N remained without undergoing any nitrification (Table 2) showing inhibition of nitrification by potassium chloride. The results of the field experiment (Tables 2 and 3) clearly showed that inclusion of commercial potassium chloride with ammonium sulphate suppressed nitrification. This suppression could have been brought by either the K-ions or the Cl-ions or any other impurity in the commercial potassium chloride.

Therefore a laboratory incubation was conducted in order to identify the source of inhibition. There was a proportionate reduction in the concentration of NO_3-N with increase in concentration of KCl used. It is interesting to note that at the highest level of KCl the nitrate concentration fell even below, that in the control (Table 4). However a suppression of nitrification of similar magnitude is also evident in the soil that received NH_4Cl without any addition of KCl. The order of suppression agrees very well with the order of chloride concentration rather than the concentration of K-ions (Table 1).

TABLE 3 — *pH of the soil (0-15 cm) and 2 N KCl extractable NH_4-N concentration in the treated soils after a two-month period of fertilizer application*

Treatment	*pH KCl*	*pH H_2O*	*NH_4-N, 2 N KCl extract (ppm)*
Control	4.00	4.65	5.8
N_1K_0	3.75	4.30	5.0
N_2K_0	3.50	3.85	3.9
N_3K_0	3.45	3.85	27.6
N_1K_2	3.90	4.55	5.9
N_2K_2	3.60	3.90	96.0
N_3K_2	3.50	3.75	166.8

TABLE 4 — *Concentration of NO_3-N (ppm) in the incubated soil after treatment*

Treatment	*Days of incubation*			
	0	7	14	21
(1) Control	12.3	38.3	33.1	22.8
(2)	12.3	55.6	61.6	57.6
(3)	12.3	44.3	49.2	49.3
(4)	12.3	40.5	41.0	39.0
(5)	12.3	27.0	25.5	21.3
(6)	12.3	30.0	28.9	26.4

Suppression of nitrification by KCl has been reported only under laboratory conditions[2]. The results from the incubation experiment confirms previous evidence that it is the chloride ion in KCl that retards nitrification. However of more importance are the results of the field experiment (Table 2) which indicates that even under field conditions control of the rate of nitrification could be achieved by a proper combination of nitrogenous fertilizers and commercial potassium chloride which is widely used in tea plantations.

At the higher levels of N the amount of NH_4-N retained in the soil 2 months after application is higher in the presence of potassium chloride than in its absence (Table 3). This indicates that a major fraction of ammonium fertilizer is retained in the soil at least for two months in the presence of potassium chloride. While the mechanism of inhibition is not clear, it has to be pointed out that the mean chloride ion concentration in the field soil solution at the end of two months was 7.1 ppm and 13.43 ppm in the K_0 and K_2 treatments respectively. The results of the laboratory incubation experiment however indicated that the chloride ion concentration required to effectively retard nitrification was much higher than the above. It is possible, therefore, that initially the retardation in nitrification is brought about by a higher concentration of chloride in a thin layer of surface soil, since the fertilizer was broadcast and not incorporated. The zero point of charge of this soil is 4.25 (unpublished) which is close to the ambient pH value of the treated plots (Table 3). Therefore one would expect an appreciable anion retention by virtue of the large positive charge on these colloids or perhaps by retention of ammonium chloride by a mechanism similar to intercalation[4]. Whatever the mechanism of inhibition the findings reported here has direct practical relevance to fertilization of tea.

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