

EFFECT OF ALUMINIUM, IRON AND MANGANESE
ON NITRIFICATION IN PEAT.

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SUMMARY

Nitrification in the presence of 0 to 3000 μg of each of Al, Fe and Mn as chlorides in peat (g^{-1}) has been studied. About up to 40 days the added elements could not produce any appreciable change in the processes of N mineralization and transformation. However, thereafter the salts suppressed nitrification and encouraged ammonification. The interalia transformation of N increased with concentration having the threshold value of 2000 μg^{-1} peat. The divergence of two trend (ammonification and nitrification) in the presence of metals attained the maximum at about 80 days. Addition of elements in freshly prepared peat was found to be more responsive than the aged one.

INTRODUCTION

A lot of research has been conducted on the role of trace elements in plant growth and the factors affecting their availability in soil, but their influence on biochemical behaviour of soil microorganisms has not received much attention. Information available suggests that addition of trace elements can alter the mode of nitrogen metabolism reactions in soil either additively or antagonistically. The critical concentration, of course, depends on the nature of element. (Lipman

and Burgess, 1914; Lees and Meiklejohn, 1948; Premi and Cornfield, 1969). Research in this respect so far has been done mainly on cultivated soils.

Studies on the role of metals in soils are difficult to plan and put into practice. The choice of medium of correct soil environment conditions for this type of experiment present problems because of the inherently high content, but not easily available, of iron and aluminium in mineral soils at normal pH; and again, of their unavailability in organic soils due to the formation of organic complexes. However, in contrast to the mineral soils, the iron and aluminium content in organic soils is generally low and becomes available only at low pH. Hence, an acid peat was chosen as the suitable medium to study the impact of metals on N transformation.

Aluminium, iron and manganese are usually dominant in acid soils; and thus, to stimulate the required soil environment metal salts of these elements were selected for application in the acid peat. The objective was to follow their ability to alter nitrogen changes through modification of the ammonifier and nitrifier activities in peat.

MATERIALS AND METHODS

Commercially available Fisons peat (I) was collected, air-dried and passed through 2 mm sieve. The physical and chemical characteristics of the peat are pH 4.3, organic matter 41.4, total N 1.6 and CEC 902 me/kg.

The experiment was carried out in two sets following a randomized block design with two replications. The first set was conducted using only one treatment- $AlCl_3$, and the second set was arranged after 4 months of the first with Fe and Mn chlorides treatments for 100 days. 50g air-dry peat was weighed out into a series of clean-dry 500 conical flasks. Five doses (0, 500, 1000, 2000 and 3000 $\mu g g^{-1}$) of aqueous solutions of each treatment applied separately. The shift of pH caused with added salts was corrected with lime as estimated from pH lime curve. The peat was incubated at 50% WHC at 25°C with clingfilm covering. A constant moisture content was maintained all through by making up the loss of moisture, and aerated every day by removing the clingfilm cover for 5 mins. Samples were collected from each flask, in triplicate, at an interval of 10 days. The collected

samples were extracted with 1M KCl for the determination of mineral-N, Al, Fe and Mn.

pH was determined by a combined glass/calomel electrode using a model 7020 pH meter (peat: water ratio being 1:2.5), in the beginning and at the end. Estimation of organic carbon by wet oxidation (Tinsley, 1970), total N by Kjeldahl digestion, CEC by 1M NH_4OAc (pH 7.0), Fe and Mn by atomic absorption spectrophotometer (Shandon Southern model A 3400), Al (Edwards and Cresser, 1983) and $\text{NH}_4\text{-N}$ and $(\text{NO}_2+\text{NO}_3)\text{-N}$ colorimetrically using a Technician Auto-Analyzer were carried out.

RESULTS AND DISCUSSION

Transformation of peat bound N in the present investigation was found to be influenced by added metals (Figs. 1A-3A). Release of $\text{NH}_4\text{-N}$ in Al-treated samples (first set) increased up to 30 days (Fig. 1A), maintained almost a steady state up to 40 days, then deviated from the control with very rapid increase and attained the maximum value on 70 days followed by a sharp decline; and then again, assumed a steady state after 90 days irrespective of the level of treatments.

In the presence of Fe and Mn (second set, Figs. 2A and 3A), the release of $\text{NH}_4\text{-N}$ reached the maximum in 20 days time followed by a sharp decline up to 40 days, thence the release increased up to 60 days and became almost steady up to 90 days (except $500 \mu\text{g g}^{-1}$) followed by a shoot up release.

Transformation trends of $\text{NH}_4\text{-N}$ are almost similar to that of the controls up to 40 days whatever may be the types and levels of treatments. The treated ones then deviated and showed upward trend whereas the control went down up to 80 days. Both the control and the treated samples resembled each other in the trend after 90 days. Lowering of C:N ratio with prolonged incubation may have accentuated the mineralization of organic nitrogen.

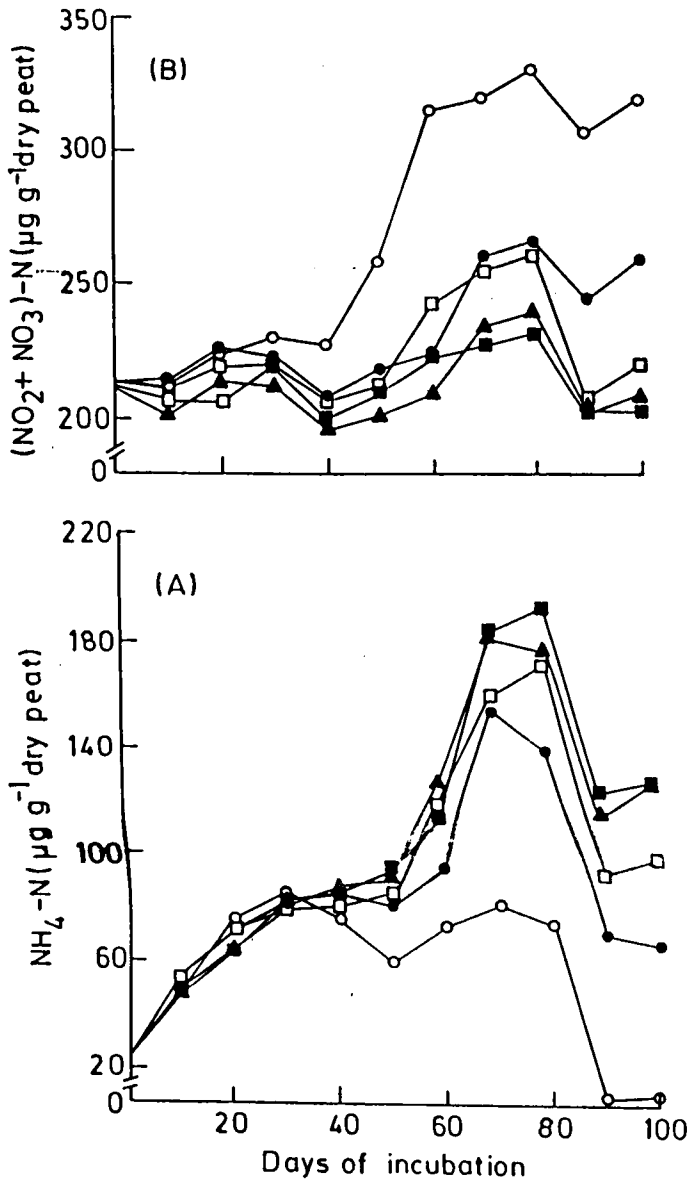


Fig. 1 Changes in $\text{NH}_4\text{-N}$ (A) and $(\text{NO}_2 + \text{NO}_3)\text{-N}$ (B) as influenced by AlCl_3 during aerobic incubation of Fisons peat (I).
 Legends : ○—○ 0/ $\mu\text{g g}^{-1}$, ●—● 500 / $\mu\text{g g}^{-1}$,
 □—□ 1000/ $\mu\text{g g}^{-1}$ ■—■ 2000 / $\mu\text{g g}^{-1}$,
 ▲—▲ 3000 / $\mu\text{g g}^{-1}$.

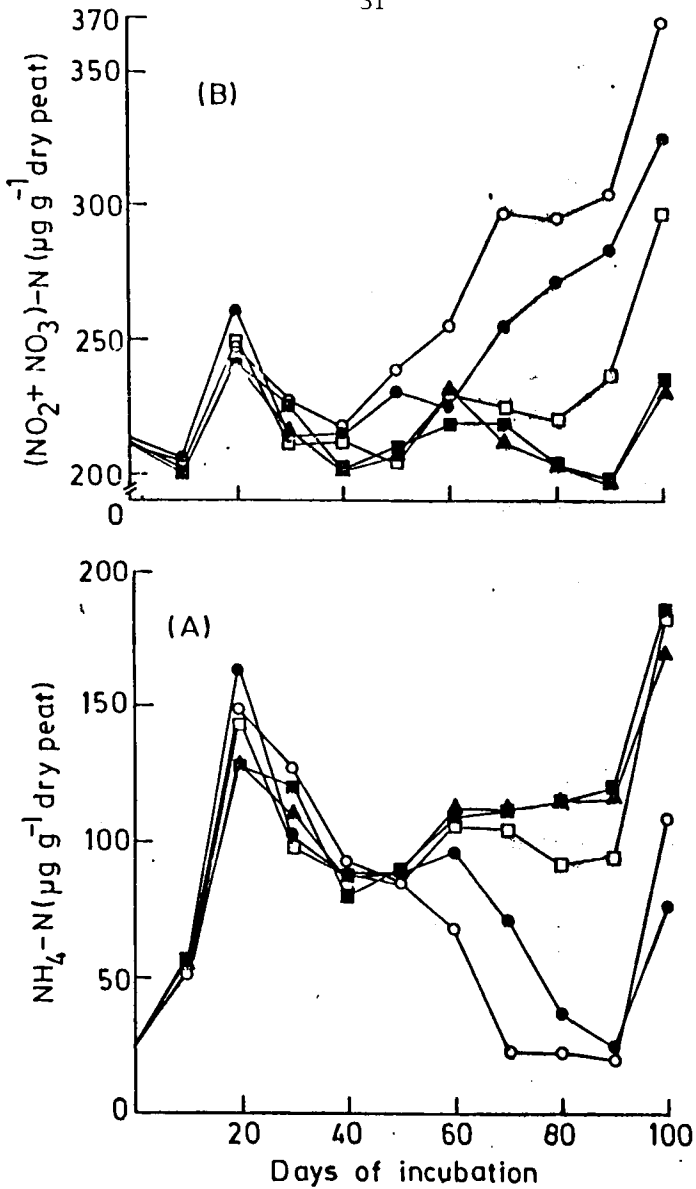


Fig. 2 Changes in $\text{NH}_4\text{-N}$ (A) and $(\text{NO}_2 + \text{NO}_3)\text{-N}$ (B) as influenced by FeCl_3 during aerobic incubation of Fisons peat (I).
Legends : see Fig. 1.

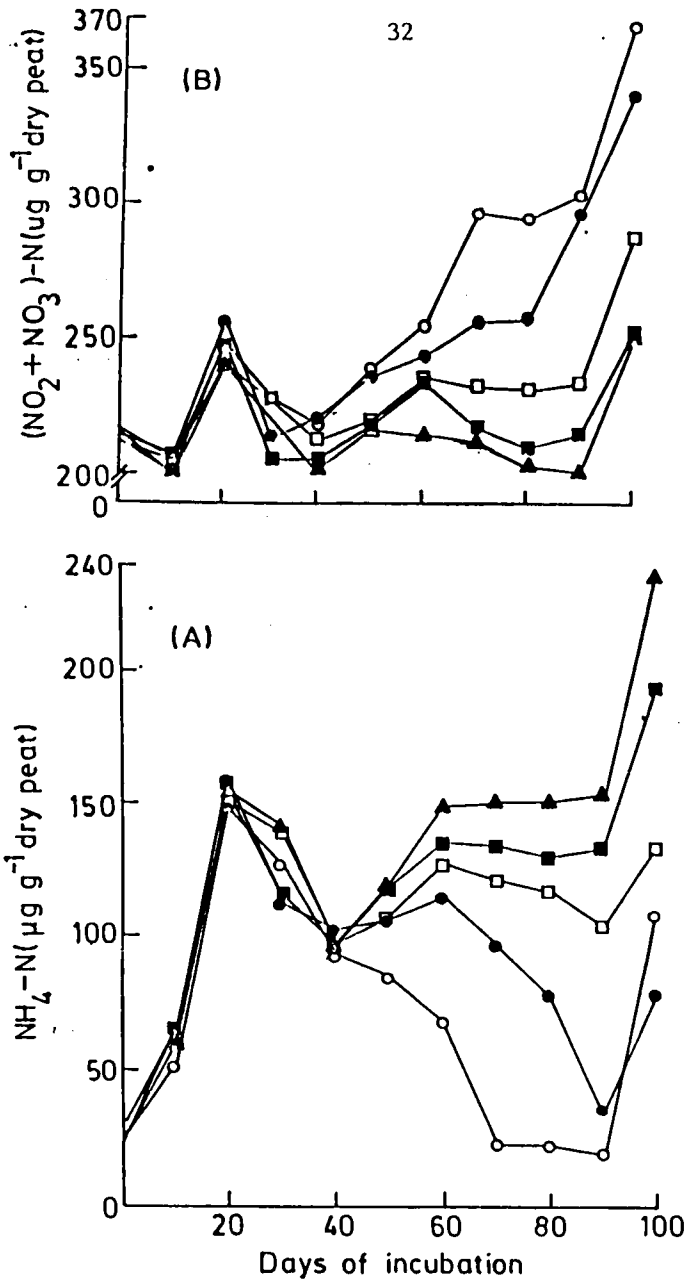


Fig. 3 Changes in $\text{NH}_4\text{-N}$ (A) and $(\text{NO}_2 + \text{NO}_3)\text{-N}$ (B) as influenced by MnCl_2 during aerobic incubation of Fisons peat (I). Legends : see Fig. 1.

It is evident from the figures (1A-3A)(first set) that the availability of $\text{NH}_4\text{-N}$ increased with the increase of the doses. Singh et al. (1969) also suggested that release of $\text{NH}_4\text{-N}$ was a direct function of concentration of chlorides of Al and ^{54}Fe in soil solution with in the limit 0 to 1M.

Comparison of the controls of the sets shows that in the second set (Fe and Mn treated experiment), the release of $\text{NH}_4\text{-N}$ increased very rapidly up to 20 days then declined almost in same rate up to 70 days, maintained equilibrium for about 20 days and then increased very rapidly. In contrast, in the first set (Al treated experiment) the control did not attain maximum at 20 days but otherwise continued to rise up to 30 days and remained almost same up to 80 days with slight fall on 50 days and a somewhat boosting on 70 days. Careful analysis reveals that the release of $\text{NH}_4\text{-N}$ in the peat is not element bound. If Fe and Mn would have been added to the peat concurrently with Al the nature of the graph could have the same sort of appearance. Nevertheless, treatment with the metals resulted positive effect over the control though at a lapse of 40 days.

Though the shapes of the graphs of Al treated vis-a-vis the control are different from those of Fe and Mn treated ones (Mn and Fe ones are virtually same), but critical examination of the graphs reveals on an first approximation that impact of metals on release of $\text{NH}_4\text{-N}$ in comparison with control in both the sets are almost equivalent i.e. the difference between the control and the treated one are almost same irrespective of time. The apparent contradictory change in the graphs between the two sets is easily comparable with the time lapse between two sets. Presumably a reconable biochemical change occurred in the peat prior to the start of the second set.

Experiment with organic soil present problems peculiar to its one time autotransformation even in the air-dried condition followed by wetting. If we compare Fig. 1A with Figs. 2A and 3A, the prominent hump is conspicuous in about 20 days time (Figs. 2A and 3A) and disappeared from the peat which was cured at room temperature for 120 days (Fig. 1A).

On comparison of both the sets of experiments at 80 day run, amount of $\text{NH}_4\text{-N}$ released was much higher in Al treated one than that of Fe and Mn treated ones. Apparent immediate $\text{NH}_4\text{-N}$ economy attainable if peat is not air-cured (Figs. 1A-3A).

The trend of release of $(\text{NO}_2+\text{NO}_3)\text{-N}$ (Figs. 1B-3B) up to 40 days were almost prototype to that of $\text{NH}_4\text{-N}$ (Figs. 1A-3A) with slight exception at 10 days in the second set where the amount of $(\text{NO}_2+\text{NO}_3)\text{-N}$ declined a little bit. However, the amount released was higher than that of $\text{NH}_4\text{-N}$ in all cases. After 40 days, $(\text{NO}_2+\text{NO}_3)\text{-N}$ graph proceeded in the reverse direction with respect to control as well as $\text{NH}_4\text{-N}$. The divergent trend of $(\text{NO}_2+\text{NO}_3)\text{-N}$ was probably due to the fact of inhibiting impact of metals on nitrifying bacteria or otherwise. The reciprocity in $(\text{NO}_2+\text{NO}_3)\text{-N}$ release was very much indicative of the fact that these metals suppressed nitrification resulting in an accumulation of $\text{NH}_4\text{-N}$ by stimulating ammonifiers. The decreased yield of $(\text{NO}_2+\text{NO}_3)\text{-N}$ was not obviously due to denitrification, because the total $\text{N}(\text{NH}_4\text{-N} + \text{NO}_2\text{-N} + \text{NO}_3\text{-N})$ at all stages of incubation were same with experimental limit with respect to control. In both the processes of N transformation all the metals were almost equally effective. Contrary to this result Greaves (1922) assessed that Fe was more toxic than Mn and Al was more detrimental in comparison to Fe (Singh et al., 1969) to activity of nitrifiers. Singh et al. (1969) also reported that Al and Fe (0 to 1M) in soil solution had very little effect on nitrification. It is peculiar to note that the control follows the trend of metal treated samples in $\text{NH}_4\text{-N}$ and Vice-versa. Nitrifiers seems to be more active than ammonifiers up to 40 days whether treated or not.

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REFERENCES

- Edwards, A.C. and Cresser, M.S. 1983. An improved, automated xylenol orange method for the colorimetric determination of aluminium. Talanta, 30(9), 702-704.
- Greaves, J.E. 1922. Influence of salts on bacterial activities of soil. Bot. Gazette, 73. 161-180.
- Lees, H. and Meiklejohn, J. 1948. Trace elements and nitrification. Nature, 161, 398-399.
- Lipman, C.B. and Burgess, P.S. 1914. The effects of copper zinc, iron and lead salts on ammonification and nitrification in soils. Univ. Calif. Publ. Agric. Sci., 1, 127-139.
- Premi, P.R. and Cornfield, A.H. 1969. Effects of addition of copper, manganese, zinc and chromium compounds on ammonification and nitrification during incubation of soil. Plant and soil, 31(2), 345-352.
- Singh, B.R., Agrawal, A.S. and Kanehiro, Y. 1969. Effect of chloride salts on ammonium nitrogen release in two Hawaiian Soils. Soil Sci. Soc. Amer. Proc., 33, 557-560.
- Tinsley, J. 1970. A manual of Experiments. Dept. Soil Sci., Univ. Aberd., Scotland, U.K. 77-81 pp.