The Influence of Fertilisers Upon Microbial Activity in Peat

I. SUPERPHOSPHATE AND GROUND MINERAL PHOSPHATE[1]

J. J. GARDINER[2] and M. J. GEOGHEGAN[3]

Introduction

GROWTH of forest trees on many of the peat types occurring in Ireland is extremely slow due to the nutritional poverty of the peats, but the addition of phosphate improves the rate of growth. In addition to this growth response to phosphate, foliar analyses have shown that uptake of nitrogen by trees from peat treated with Ground Mineral Phosphate (G.N.A.P.) is much higher than that from untreated peat.

This increase in foliar nitrogen concentration has been attributed to an increase in availability of mineral nitrogen in the peat following phosphate application. It has been suggested (McEvoy, 1954; Atterson and Binns, 1968; O'Carroll, 1972) that the calcium in the G.N.A.P. (rock phosphate) stimulates the microbial population resulting in increased mineralisation of organic nitrogenous complexes. However, O'Hare (1967) could not measure any growth response in trees following application of calcium carbonate to peat. In fact growth decreases following liming have been reported (e.g. Dickson, 1972).

The purpose of the experiments reported here was to measure the effects of superphosphate and G.N.A.P. upon microbial activity in peat, and its influence on some of the chemical properties of the peat.

Experiments

The peat used was cut-over raised bog peat remaining after the milled peat method of harvesting was collected from Bay 21, Lullymore, Co. Kildare (Grid ref. N70.26). The final harvesting from this bay was in 1965 and the remaining peat has been exposed and undisturbed since that time. It is a layered non-sphagnum-moss peat of average pH 4.5. The peat was homogenised by sieving before addition of the fertilisers.

---

1. Part II: *Calcium and Nitrogen* wll be published in Vol. 32, No. 2.
2. Forestry Department, University College, Dublin.
3. Department of Industrial Microbiology, University College, Dublin.

G.N.A.P. and superphosphate were added separately to the homogenised cut-over peat at rates of 0 (P_0), 625 (P_1), 1250 (P_2) and 2500 (P_3) kilograms of fertiliser per hectare. No attempt was made to add equivalent amounts of the elements. These rates were calculated from bulk density measurements. The treated peat samples were incubated in pots in the laboratory and the moisture content was maintained at field level (82% wet weight) for the duration of the experiment. The mean temperature in the laboratory during this period was 20.5°C±4.5°C.

Microbial activity was assessed by measuring oxygen uptake, ammonical (NH_4—N), and nitrate ($N0_3$—N) nitrogen and pH were determined at intervals over a period of 70 days. Oxygen (0_2) uptake by the peat was measured using the electrolytic macro-respirometer of Birch and Friend (1956) as modified by Balis (1973). (Fig. 1). NH_4—N and $N0_3$—N were extracted by shaking with 1N—K_2 $S0_4$ and estimated by the microdiffusion method of Bremner and Shaw (1958). pH was mesured on a peat paste (peat: water, 1:2) using a glass electrode. The bacterial and fungal populations were estimated by the plate dilution method on the 70th day.

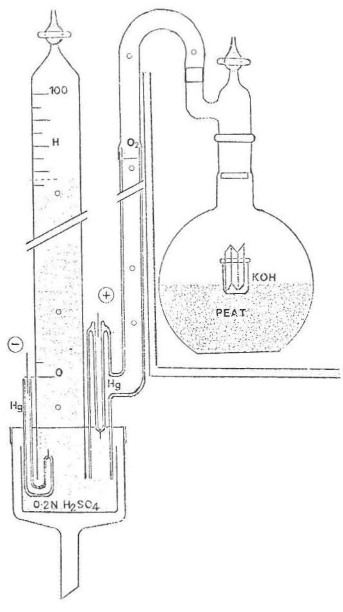

Figure 1. The macrorespirometer used for measuring oxygen uptake.

TABLE 1

INFLUENCE OF PHOSPHATE TREATMENT ON pH OF PEAT

Super-phosphate	Time (Days)						Mean
	1	7	14	28	52	70	
P_0	4.40	4.35	4.35	4.40	4.35	4.35	4.37
P_1	3.90	3.90	3.90	3.90	3.90	3.95	3.91
P_2	3.80	3.80	3.85	3.90	3.95	3.95	3.88
P_3	3.70	3.75	3.75	3.80	3.80	3.80	3.77
Means	3.95	3.95	3.96	4.00	4.00	4.01	
G.N.A.P.							
P_0	4.35	4.35	4.35	4.35	4.40	4.40	4.37
P_1	4.30	4.25	4.25	4.25	4.30	4.30	4.27
P_2	4.30	4.25	4.25	4.25	4.30	4.35	4.28
P_3	4.25	4.20	4.20	4.20	4.25	4.40	4.25
Means	4.30	4.26	4.26	4.26	4.312	4.362	

L.S.D. (5% level) Superphosphate 0.03 G.N.A.P. 0.02

Results

1. *Effect of Treatment on pH of Peat*

Immediately following mixing of the peat and fertilisers, slight decreases in pH were found in all of the peat samples (Table 1). This drop in pH was more noticeable after 7 days incubation. However, the pH of the G.N.A.P. treated peat samples reverted to near its original level towards the end of the experimental period.

This initial decrease in pH was rather surprising in view of the amount of calcium which the fertilisers contain (Sauchelli, 1956), although the differences in effect between the fertilisers can be explained by differences in calcium content. However, Carolan (1959) has shown that the effect of G.N.A.P. on pH varies in different peats and he cites similar reports from Russian workers. With lowmoor peat—G.N.A.P. mixtures he found an increase in pH at first, followed by a decrease; transitional peat—G.N.A.P. mixtures showed a steady decrease in pH.

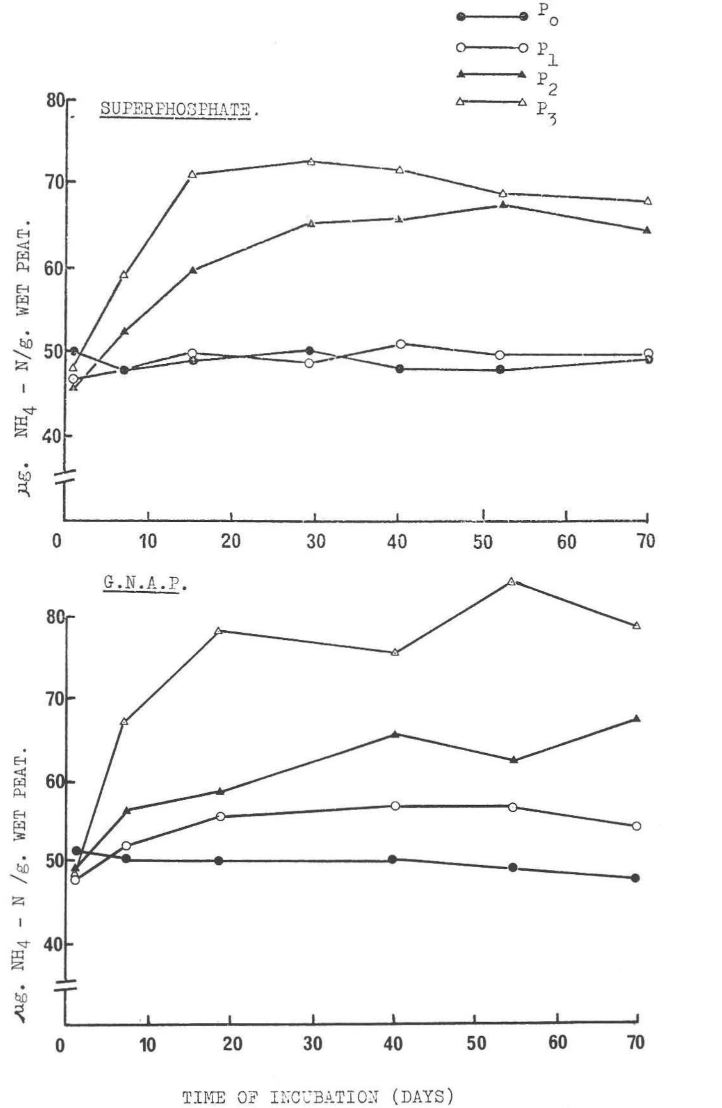

Figure 2. Influence of phosphate treatment on concentration of NH4-N in peat.

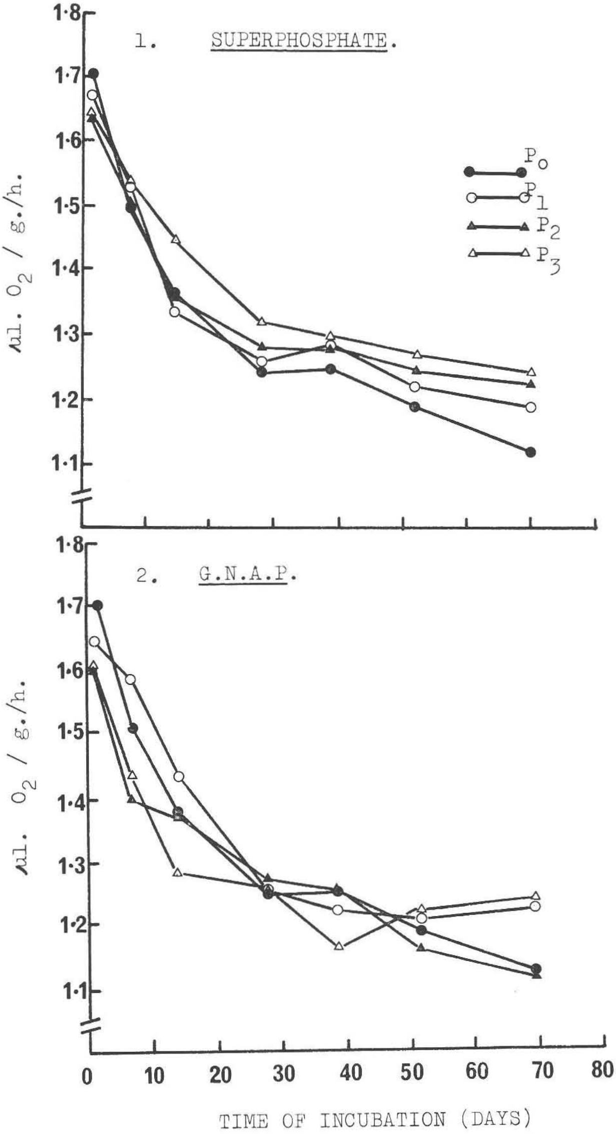

Figure 3. Influence of phosphate treatment on the rate of oxygen uptake in peat.

2. *Effect of Treatment on Nitrogen Content of Peat*

(a) Ammoniacal Nitrogen

The NH_4—N content of the peat increased significantly following the addition of both fertilisers, at all levels of application with the exception of the lowest level of superphosphate (Fig. 2). The highest concentrations of NH_4—N occurred in both instances with the largest application of fertilisers. The increases in the mineral nitrogen concentration of the P_2 and P_3 were significant at the 1% level.

(b) Nitrate Nitrogen

The NO_3—N content of the peat samples remained constant throughout the experiment and ranged from 3–7 micrograms/gram of wet peat.

3. *Effect of Treatment on Oxygen Utilisation of Peat*

The rate of O_2 uptake by all treated peat samples (including control) decreased steadily over the first 30 days of incubation, thereafter the rate of decrease tended to level off. This is illustrated in Fig. 3. Rate of uptake ranged from 1.7 to 1.1 microlitres of oxygen/gram/hour at the beginning and end of the incubation period.

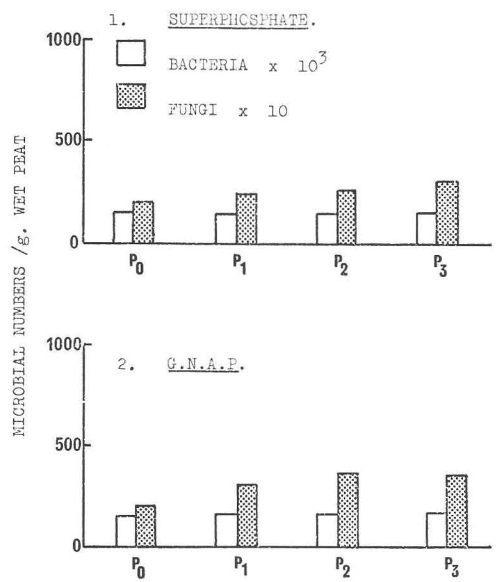

Figure 4. Influence of phosphate treatment on microbial numbers in peat.

This decrease was probably due to the fact that the respiration rate was already unusually high following aeration during sampling and homogenisation. Jackman (1960) has found that some of the oxygen uptake by disturbed soil may be non-biological and attributable to autoxidation of lignin. From about the 30th day of incubation onwards small differences in the rate of respiration of the peat samples were found, but these were not statistically significant. The numbers of bacteria counted at the end of the period, were not influenced in any way by either fertiliser at any level of application (Fig. 4). Small increases in fungal numbers in the peat were found at the 70th day, but the variation between fungal counts within treatments was usually greater than the differences between treatments.

Discussion

The application of different rates of superphosphate and G.N.A.P. separately at various levels has led to an increase in concentration of NH_4—N in the peat. Furthermore, the biggest increases in mineral nitrogen were found at the highest levels of fertiliser application. This may account for the finding by O'Carroll (1972) that the smaller the application of G.N.A.P. the shorter the period during which growth accelation of Sitka spruce is maintained. Despite the effect of superphosphate upon the availability of mineral nitrogen shown here, application of superphosphate has been found to be less effective than G.N.A.P. in improving tree growth on peat. (O'Carroll 1972, and personal communication.) This may be due to the lowering of the pH of the substrate by the former (Table 1). Benzian (1965) has shown that for nursery plants at least optimum uptake of nitrogen by Sitka spruce and Lodgepole pine occurs close to pH 4.5 and drops off steeply below pH 4.0. The final pH levels found in the superphosphate treated peats in these experiments were as low as 3.8.

The results indicate that the addition of G.N.A.P. to peat produced an increase in the concentration of NH_4—N in the peat, yet no increase in microbial numbers or activity (0_2 uptake) has been observed. These facts indicate that the reactions involved in the release of the additional NH_4—N are chemical and not biological. Neither is there any evidence that there is an increase in microbial activity following the addition of superphosphate. Indeed, Williams (1972) has reported that the addition of triple-superphosphate to pine-humus, apart from stimulating mineral nitrogen production, had no effect upon microbial activity measured as $C0_2$ production.

From the above it may be concluded that the addition of soluble or insoluble phosphatic fertilisers to cut-over peat does not stimulate microbial activity and has no priming effect upon the microbial population. This is contrary to the findings of Zottl (1963) who reported that basic slag stimulated microbial activity and nitrogen mineralisation in peat. However, it should be noted that in his case the phosphate was added with lime. In addition, Dickson and Savill (1974) have shown that a second application of G.N.A.P. to crops growing on peat has only a small and short-lived effect upon foliar nitrogen concentration. Also, since it appears that there is no "priming effect", the nitrogen supply to trees growing on peat can only be maintained by either promoting recycling of nutrients from the peat or by direct application of nitrogenous fertilisers.

References

Atterson, J. and W. O. Binns (1968). Nutrition of Forest Crops. Report of the Forestry Commission on Forest Research. 45.

Balis, C. (1973). Soil Respirometric Technique. Paper presented at 2nd Inter. Cong. Plant Pathology, St. Paul, Minnesota.

Benzian, B. (1965). Erperiments on Nutrition Problems in Forest Nurseries. Vol. I. H.M.S.O. (Lond.). 44.

Birch, H. F. and M. T. Friend (1956). Humus Decomposition in East African Soils. Nature (Lond.). *178,* 500.

Bremner, J. M. and K. Shaw (1958). Denitrification in Soil. II Factors Affecting Denitrification. J. Agric. Sci. *51,* 40.

Carolan, R. (1959). Solubilisation of Phosphate Rock by composting with peat. J. Sci. Fd. Agric. *10,* 207.

Dickson, D. A. (1972). Effects of Limestone, Phosphate and Potash on the early growth and Nutrient Uptake of Sitka spruce (*Picea sitchensis* (Bong. Carr.) planted on deep peat in Northern Ireland. Proc. 4th Inter. Peat Cong. Helsinki.

Jackman, R. H. (1960). Organic Matter Stability and Nutrient Availability in Taupo Pumice. New Zealand J. Agric. Res. *3,* 6.

McEvoy, T. (1954). Afforestation of Peat Soils. Inter. Peat Symposium, Dublin. Ir. For. *11,* 65.

O'Carroll, N. (1972). Studies on Fertilisation, Soil Cultivation and Planting Techniques in their Effects on Growth and Yield of Forest Crops. Ph.D. Thesis, University College, Dublin (unpublished).

O'Hare, P. J. (1967). Leader Growth and Foliar Composition in Sitka spruce (*Picea sitchensis* Carr.) in Relation to Fertiliser Application on Blanket Peat. Proc. fifth Colloquium on Forest Fertilisation. Int. Potash Inst., Jyväskylä, Finland, III.

Sauchelli, V. (1956). Phosphates in Agriculture. Reinhold Publishing Corp., New York.

Williams, B. L. (1972). Nitrogen Mineralisation and Organic Matter Decomposition in Scots pine Humus. Forestry *45,* 177.