SOIL DENITRIFICATION IN SEALED SOIL-PLANT SYSTEMS

I. EFFECT OF PLANTS, SOIL WATER CONTENT AND SOIL ORGANIC MATTER CONTENT

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SUMMARY

Evolution patterns and constituent components of denitrification have been measured in sealed soil–plant systems. In two samples of the Urrbrae red-brown earth containing 1.6 and 2.3% organic C, respectively, the growth of the plant consistently increased the amounts of N₂O and N₂ from the soil at all water contents below field capacity. At soil water contents above field capacity, the total losses of soil nitrogen were limited in the pasture soil (org. C 2.3%) by the amount of nitrate substrate and in the crop soil by the lack of easily decomposable soil organic matter. The yields of plant tops were low in these treatments.

In the presence of plants, N₂ was evolved preferentially, while in their absence N₂O accounts for most of the soil nitrogen loss. This trend was most pronounced in the crop soil.

The pore space relationships measured at the end of the experiments showed that potential oxygen diffusion pathways were more restrictive in the crop soil than in the pasture soil. The plant effect on soil denitrification was two-fold, firstly by increasing the demand for oxygen in the soil and secondly by supplying easily decomposable organic matter.

INTRODUCTION

Losses of soil nitrogen as volatile products have been shown to be increased by the growth of plants in pots 16 and in sealed growth chambers 14. Woldendorp 16 found that plant roots which supported an active rhizosphere population stimulated the loss of soil nitrogen as denitrification products. In sealed growth chambers 14 considerable amounts of nitrogen and nitrous oxide appeared in the gaseous phase of the soil–plant atmosphere under a wide range of
soil conditions. Where the soil water content was less than field capacity, the growth of plants increased the quantities of nitrogen and nitrous oxide. In these systems, quantitative estimation of the volatile forms of nitrogen was possible as well as changes in the evolution patterns which occurred with differing soil conditions. In both the open and closed systems, the denitrification was probably a biological process occurring in anaerobic microsites in a partially aerobic soil.

Burford and Millington have shown the presence of N$_2$O in the surface soil of the Urrbrae red-brown earth after rain. Because of the diverse nature of the source and diffusion rates, these authors were unable to make an accurate estimate of the losses of soil nitrogen as nitrous oxide in the field. In later work, the determinations of nitrogen to argon ratios did not permit the evaluation of N$_2$ as a denitrification product in field soils.

In the present experiment, sealed growth chambers have been used to establish the effect of soil organic matter content and soil water content on the evolution pattern and the constituents of nitrogenous gases evolved from a soil–plant system.

**MATERIALS AND METHODS**

**Soils**

The Urrbrae red-brown earth was sampled from contiguous areas which had been either under an annual pasture of *Trifolium subterraneum* and *Lolium rigidum* for the previous 10 years or had been cropped continuously with cereals for the last 10 years. Both sites had received annual top-dressings of superphosphate. These soils are referred to in the text as pasture and crop soils, respectively. The 0–10 cm samples were collected in an air-dry state and passed through a 0.6-cm rotary sieve.

**Sealed growth chambers**

The sealed growth chambers, ancillary equipment and the operational techniques have been described elsewhere.

**Methods of nitrogen analyses**

The total soil nitrogen including inorganic nitrogen was determined by Kjeldahl digestion on air-dried samples taken before and after the experimental period. The nitrogen contents of the plant material were estimated by micro-Kjeldahl. The water vapour from evapotranspiration was condensed and passed through a cation exchange resin. Ammonium was determined in the washings from the resin at the end of the experiment. A vial of 40% w/v KOH was included in each chamber to absorb the CO$_2$ evolved from the