GASEOUS LOSSES OF NITROGEN FROM SOILS BY DENITRIFICATION

A Thesis submitted
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to the University of Adelaide
for the degree of
Doctor of Philosophy

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September, 1969.
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SUMMARY

The occurrence of denitrification products in the soil atmosphere of the Urrbrae fine sandy loam, a red-brown earth, has been investigated over the three year period 1966-68. Samples of the soil air were obtained from small, permanently installed reservoirs (30 ml capacity) and analyzed by gas chromatography for $N_2$, $N_2O$, $CO_2$, $O_2$ and $A$.

The detection of nitrous oxide in the soil atmosphere for periods of 2-6 months in each year demonstrated the normal occurrence of denitrification in this agricultural soil, and confirmed earlier predictions that aerobic denitrification can result in the gaseous loss of nitrogen from agricultural soils in the field: the mean oxygen concentrations in the large soil pores were always greater than 10% and usually greater than 15% in the B horizon and 18% in the A horizon. The mechanism responsible for the losses was that of biological dissimilation at anaerobic micro-sites within the generally well aerated soil.

A preliminary experiment indicated that the dissolution of evolved $CO_2$ in the soil water could create pressure gradients and the mass flow of soil air; it was shown that estimates of the losses as nitrogen gas could not be obtained from measurements of the nitrogen gas concentrations alone. The use of argon as a reference gas was investigated, but differences in the diffusion rates of $N_2$ and $A$ prevented measurement of the evolution of $N_2$ gas from $N_2/A$ ratios.
The nitrous oxide measurements indicated that there were
two main sources of evolution in the soil profile: a zone in the
$A_1$ horizon at about the 10 cm depth, and one in the $B$ horizon at about
the 60 cm depth. The occurrence of $N_2O$ in the $A_1$ horizon was
ephemeral and restricted to brief periods when the soil moisture
content was high following rainfall. In contrast, $N_2O$ concentra-
tions were much less variable in the $B$ horizon: in each season the
gas was detected after the initial wetting of the subsoil in late
autumn and levels increased to a peak in mid-winter then decreased
in late winter and early spring.

Calculations based on transfer equations were unsatisfactory
for accurately estimating losses, mainly due to uncertainties in the
values for the air-filled porosity of the soils. However, such
calculations indicated that losses were much greater from the $A_1$
than from the $B$ horizon, despite the usually brief occurrence of
$N_2O$ in the $A_1$ horizon. The greatest losses from both horizons were
in winter when soil temperatures were lowest ($10 \pm 5$ C) and soil
moisture contents highest.

Losses under a wheat crop were not markedly different on
two areas with contrasting structure and organic matter status, but
losses underneath a pasture were much smaller than under the wheat
crop.

The application of nitrate fertilizer (100 lb/acre) increased
$N_2O$ evolution 3-10 fold in the $A_1$ horizon and up to 2.5 fold in the $B$
horizon, but the estimated maximum diffusive losses were only 0.06-0.67 lb N₂O-N/acre/day from areas sown to wheat and fertilized with nitrogen.