SEASONAL VARIATIONS IN THE LEVELS OF MINERAL NITROGEN IN TWO SOILS UNDER DIFFERENT MANAGEMENT SYSTEMS

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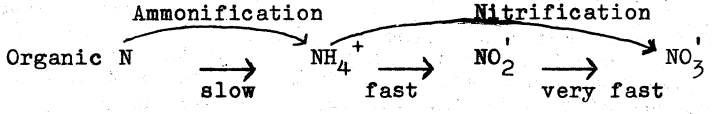
INTRODUCTION

Very little research has been undertaken investigating the levels of mineral nitrogen at different times of the year in arable soils in New Zealand. In thepast 20 months the levels of mineral nitrogen in two soils under different management systems at Lincoln College have been investigated. This paper is a preliminary report on these studies.

Most nitrogen in soils is organically bound and is not available to growing plants unless it is mineralised by micro-organisms to the inorganic forms; namely ammonium, nitrite and nitrate. On most soils the amount of nitrite present is negligible. It is generally agreed that 2-4% of the total nitrogen is mineralised annually. The process of mineralisation of organic nitrogen can be summarised as follows:



Ammonification and nitrification are carried out by different groups of micro-organisms. The factors which effect mineralisation are:

1. Carbon : Nitrogen ratio of the soil
2. Tillage which enhances mineralisation
3. Factors affecting the biological environment
   - 3.1 pH
   - 3.2 Mineral nutrients
   - 3.3 Aeration.
   - 3.4 Temperature
   - 3.5 Moisture

Nitrification is more sensitive to these environmental factors than is ammonification.

METHODS

1970 Studies

From January 1970 until January 1971 on a Paparua sandy loam a study was undertaken to investigate the levels of mineral nitrogen in the soil and crop under three different systems. A two year old perennial ryegrass white clover pasture was selected for study. The following treatments were imposed:-

1 Fallow. Rotary cultivated 5 February 1970.

2 Newly Established Italian Ryegrass. Cultivated 5 February and ryegrass sown 10 March 1970.

3 Established Ryegrass Pasture. The plots were sprayed on the 19 February with dicamba to control white clover.

The fallow plots were not cultivated again throughout the length of the experiment, apart from shallow hoeing to keep the plots free of vegetation.

The plot sizes were kept small (4 meter x 1 meter) and each treatment was replicated four times making twelve plots in the trial.

The depths of sampling were 0-7.6, 7.6-15.2, 15.2-30.5, 30.5-45.7, 45.7-61.0 cm. For sampling with a 2.5 cm diameter tube sampler the plots were divided up into four 1 meter square plots. For the 0-7.6 cm samples two cores were taken from each meter square and were bulked to form one sample; thus giving four samples per plot. For the other horizons for which the standard errors were much lower, only one core from each meter square plot was taken and two of these were bulked to give 2 samples per plot.

The soils were sampled at intervals of approximately six weeks.

The herbage was cut on treatments 2 and 3 and dry matter yields kg/ha were determined and also the percentage nitrogen in the herbage using the micro-Kjeldahl method (Bremner, 1965). From these data the yields of nitrogen in kg/ha were calculated.

The amounts of ammonium nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N) were determined by taking 20 gm of soil (ex 2mm sieve) and extracting with 1N K_2SO_4 in 2N H_2SO_4 and then taking 10ml of the filtrate and using the micro-Kjeldahl steam distillation method according to Bremner (1965). Data were expressed for both NH_4-N and NO_3-N as ppm. nitrogen. Bulk density determinations were made and hence it was possible to determine the kg/ha of NH4-N and NO_3-N. Simultaneously soil samples were taken for gravimetric moisture determinations.

Negligible quantities (< 1 ppm) of nitrite nitrogen were shown to be present in the soil in the first five samplings.

1971 Studies

A study was commenced in late February 1971 to investigate the levels of mineral nitrogen in the different nitrogen treatments in a trial on second year wheat. The four rates of nitrogen by four rates of phosphate factorial trial was laid down by Mr R.C. Stephen, Scientist, Field Research Section, Department of Agriculture. The soil type was the Wakanui silt loam on sandy loam weakly mottled phase.

In this preliminary report the levels of mineral nitrogen are given for fallow plots on the control treatment in the rates of nitrogen by rates of phosphate trial. When the wheat emerged through the ground in control treatments in July it was hoed off at nine locations in the 50 metre plot. The size of the nine fallow plots were 3 metres x 1 drill width.

The stubble from the preceding 1970/71 wheat crop was burnt on the 25 February 1971. The burnt stubble was left over the drought period until the first cultivation with a grubber on the 11 May; it was grubbed twice on this date. A further rolling and grubbing was carried out on 28 May and the trial was drilled on 16 June.

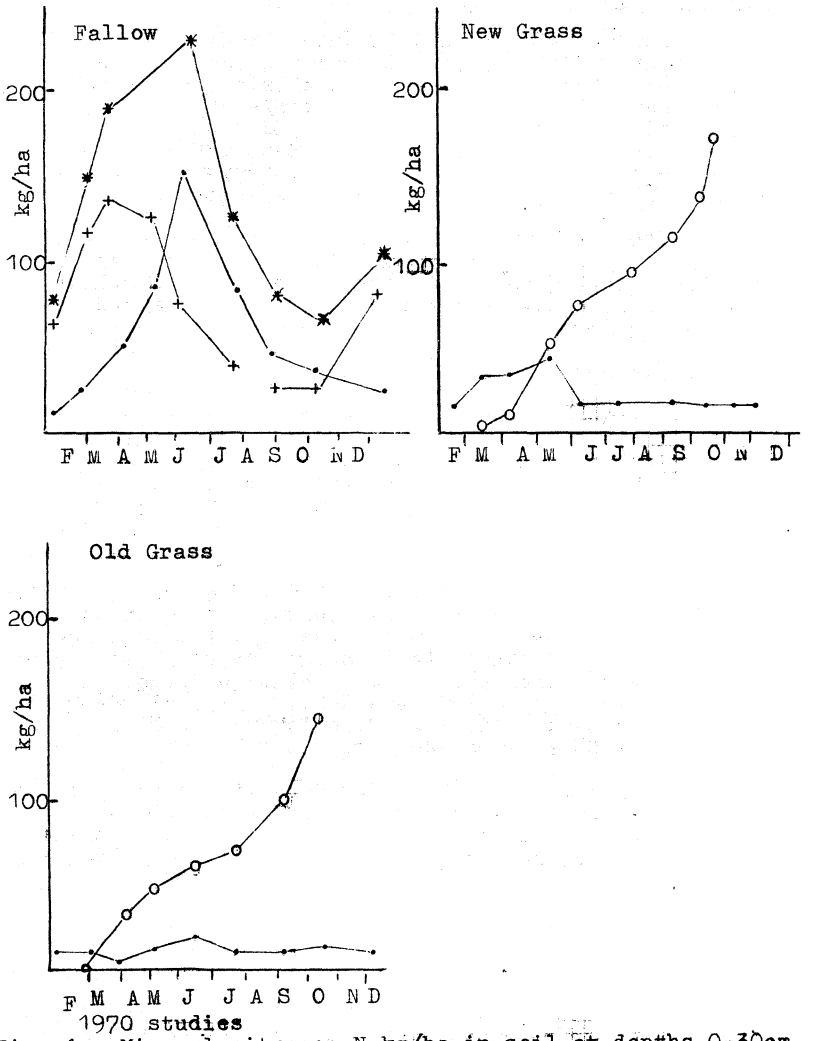
The depth of sampling were 0-10, 20-40 and 60-95 cm. The 60-96 cm samples are collected with a power auger. A 2.5 cm diameter tube sampler was used for sampling the other four depths. At each time of sampling, samples were collected from three of the nine locations at random. Each sample from the 0-10, 10-20 and 20-40 cm depths consisted of four cores which were bulked; for the 40-60 cm depth two cores were bulked.

The analytical methods for determining the ppm NH_4-N and NO_3-N were the same as those used in the 1970 study. The percentage moistures and bulk density were determined for each depth at each time of sampling.

RESULTS

1970 Studies

1. Fallow Treatment. The amounts of mineral nitrogen NO_3-N and NH_4-N in kg/ha on the various sampling dates in the fallow treatment are shown in Figure 1. Cultivation in early February led to a two-fold increase in total mineral nitrogen (58 - 120 kg/ha) in the top 30 cm of soil by early March; the increase was mainly in NO_3-N. The levels at this depth remained similar until mid-May.



1970 studies

Fig. 1. Mineral nitrogen N kg/ha in soil at depths 0-30cm + —+, 30-76 cm .—. and 0-75cm * - * and cumulative sums of nitrogen kg/ha in herbage 0 - 0.

The nett mineralisation in the whole 30 inch depth of profile increased from 74 kg/ha in early February to 231 kg/ha in late June. In the 30-75 cm depth the levels of mineral nitrogen increased from 17 kg/ha in late January to 155 kg/ha in late June. It was shown that a very big proportion of the mineral nitrogen at the 30-75 cm depth came from the leaching of NO_3-N from the top 30 cm.

The levels of mineral nitrogen in the 0-30 cm depth dropped from 127 kg/ha to 22 kg.ha between mid-May and late September; a loss of 105 kg/ha. The levels of mineral nitrogen in the whole 75 cm profile depth declined from 231 kg/ha in late June to 62 kg/ha in mid-November; a loss of 169 kg/ha. In figure 2 the ppm of NO_3-N at various depths on the different sampling dates are given. The downward movement of nitrate ions in this fallow treatment as the soils become moist in the autumn and winter is clearly shown. A strong correlation was shown between the mean downward movement of nitrate ions and rainfall. Also there was a highly significant (1% level) correlation between the changes in nitrate concentration and moisture percentages at the wetting front; confirming that the movement of nitrate ions follows the wetting front. During 1970 this Paparua soil remained at field capacity from early April until early August.

There was no evidence of downward movement of ammonium ions.

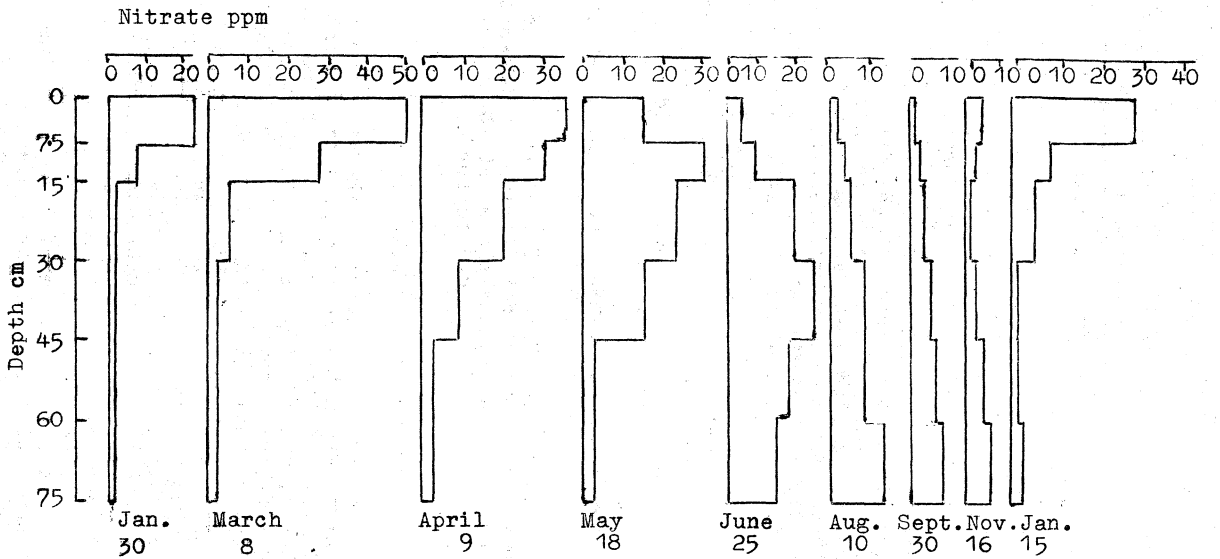
It should be noted from Figure 2 that there is no evidence of upward movement of nitrate ions in November. It is considered that the high levels of NO_3-N in the fallow soils in January 1971 are due to further mineralisation.

2. Newly Established Ryegrass Treatment.

As shown in Figure 1, the total uptake of nitrogen, including the nitrogen in the roots, up to mid-November in the establishing Italian ryegrass treatment was 173 kg/ha. This figure is very similar to the total losses under the fallow treatment of 169 kg/ha. There was some evidence of small leaching losses of mineral nitrogen of 24 kg/ha during the establishment phase between March and mid-May; this is shown in the build-up of mineral nitrogen in the 30-75 cm depth from 17 kg/ha in late January to 44 kg/ha by mid-May and by the decline to about 20 kg/ha in subsequent samplings.

3. Established Pasture

High levels of mineral nitrogen (58 kg/ha) accumulated after the senescence of the established pasture in early February 1970 (Figure 1). With the onset of growth after rains NO_3-N was rapidly depleted by mid-winter and remained like this right through the spring and early summer. In the established pasture the total



1970 Studies

Fig. 2. Nitrate concentrations ppm in Paparua soil under fallow treatment at various depths 0-7.5 cm, 7.5-15 cm, 15-30 cm, 30-45 cm, 45-60 cm and 60-75 cm.

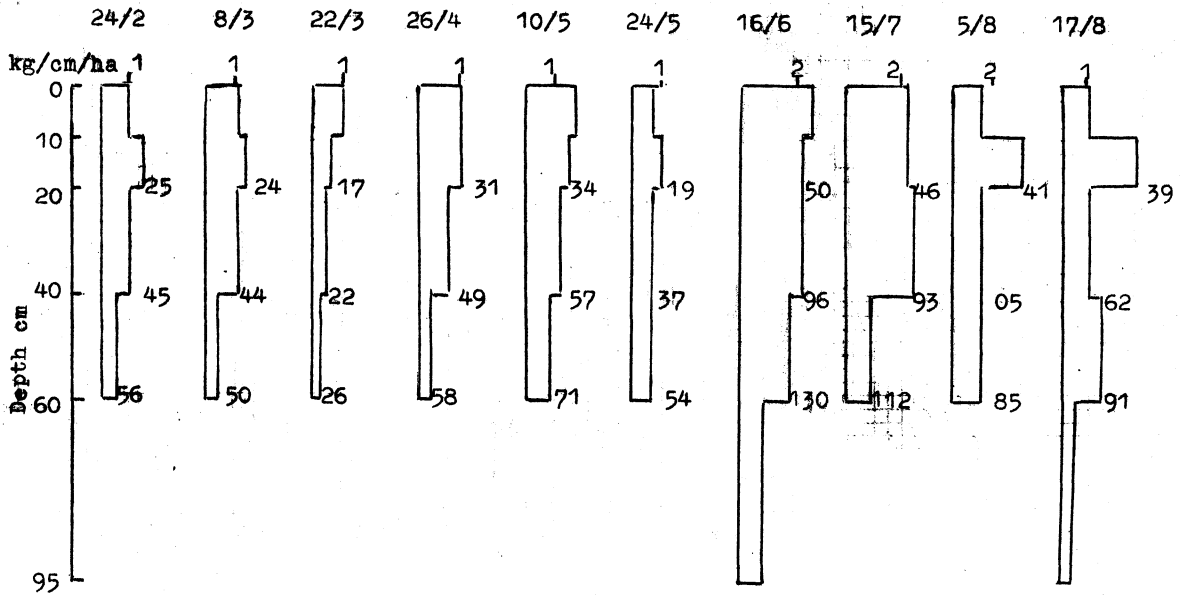


Fig. 4 1971 Studies NH_4-N kg/cm/ha in soil at various depths on different sampling dates.

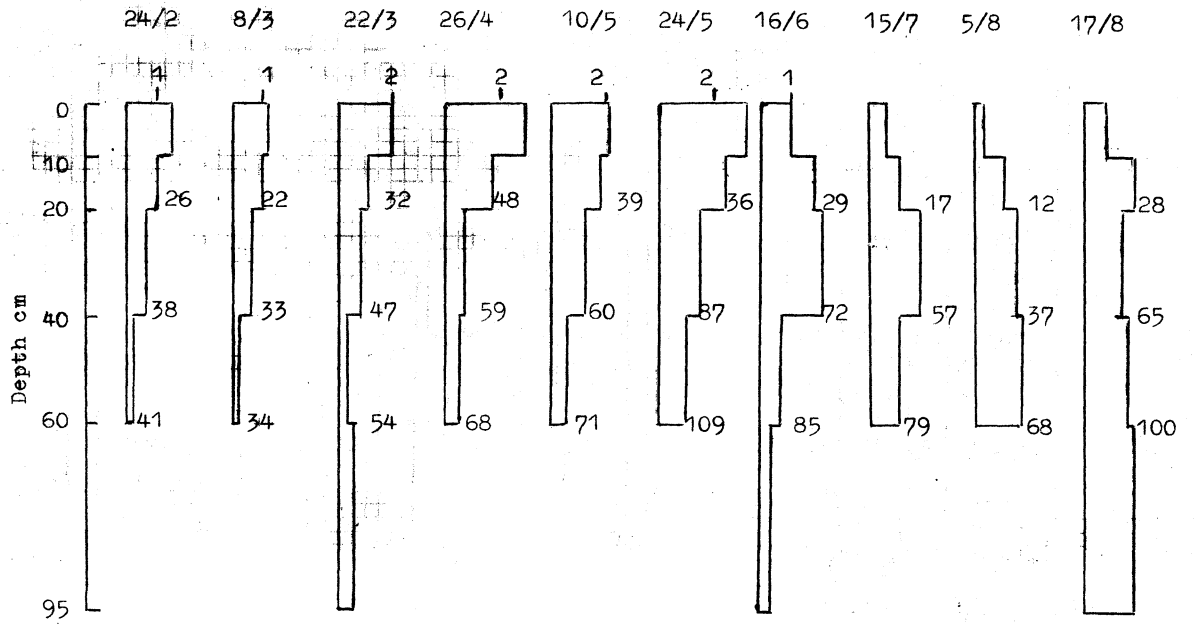


Fig. 5. 1971 Studies. NO_3-N kg/cm/ha in soil at various depths on different sampling dates.

Mineral Nitrogen Levels

The very high levels of mineral nitrogen in the soil should be noted. When the wheat was drilled on 16 June there was a total of 215 kg/ha of mineral nitrogen in the 60 cm profile. In mid-August there was 193 kg/ha of mineral nitrogen.

DISCUSSION

Both studies have shown that cultivation markedly enhances mineralisation of organic nitrogen. Where the soil is fallowed over the late autumn and winter period there may be appreciable losses of NO_3-N. The magnitude of the losses depends on the soil moisture conditions.

Under current mixed cropping practice in Canterbury in the preparation of land for wheat, the "old" pasture is usually topworked three or four times in late February and March to kill ryegrass and promote mineralisation. Seedbed preparation is usually carried out in late May for sowing in June. Where wheat is to follow wheat, the stubble is burnt after harvest and seedbed preparation is usually done in late March. The results of these studies suggest that cultivation should be left as late as possible and that there should be a minimal elapse of time between cultivation and sowing the crop. It is considered that long fallows are no longer necessary because of the low C : N ratio of so called 'old' pastures of today.

At the present time four other identical studies to the 1971 study are being undertaken in Canterbury. In each of these studies there have been very high levels of mineral nitrogen in the soils to a 60 cm depth in August 1971 (180-260 kg/ha of N). In view of these findings it is not surprising that Stephen (1970) reported that in 23 Rates of Phosphate by Rates of Nitrogen trials on wheat carried out in the 1969/70 season, nitrogen responses were only obtained in four trials.

ACKNOWLEDGEMENTS

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