N MINERALISATION AND NITRIFICATION IN CROP AND PASTURE SOILS

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Abstract

Field and laboratory studies demonstrate that N mineralisation and nitrification are concentrated in the surface few centimetres of soil. These observations were related to the decrease in the organic N concentration and pH with depth through the surface 10 cm of soil. The implications for N supply to crops and pastures, soil acidification rates and placement of ammonium based fertilisers are discussed.

Key words: Distribution, Riverina region, management implications, review of recent work.

In crop and pasture rotations unless N fertilisers are applied, nitrate for non-leguminous plants originates from the mineralisation of organically bound N followed by nitrification. As both are biological processes their rate is controlled by the concentration of the substrate and the soil environment (moisture, aeration, temperat-ure, and pH).

Most studies investigating the supply of N from soils consider that the N is released in the surface 10 to 15 cm of soil. However work in the U.S.A. has shown that the concentration of organic N decreases rapidly through the surface 10 cm of soil (4). In addition, soil pH decreases through depth in pasture soils (2). These observations lead us to consider that in pasture and cropping soils that were minimally disturbed, mineralisation and nitrificat-ion may be confined to the surface few centimetres of soil.

Distribution of N mineralisation with depth

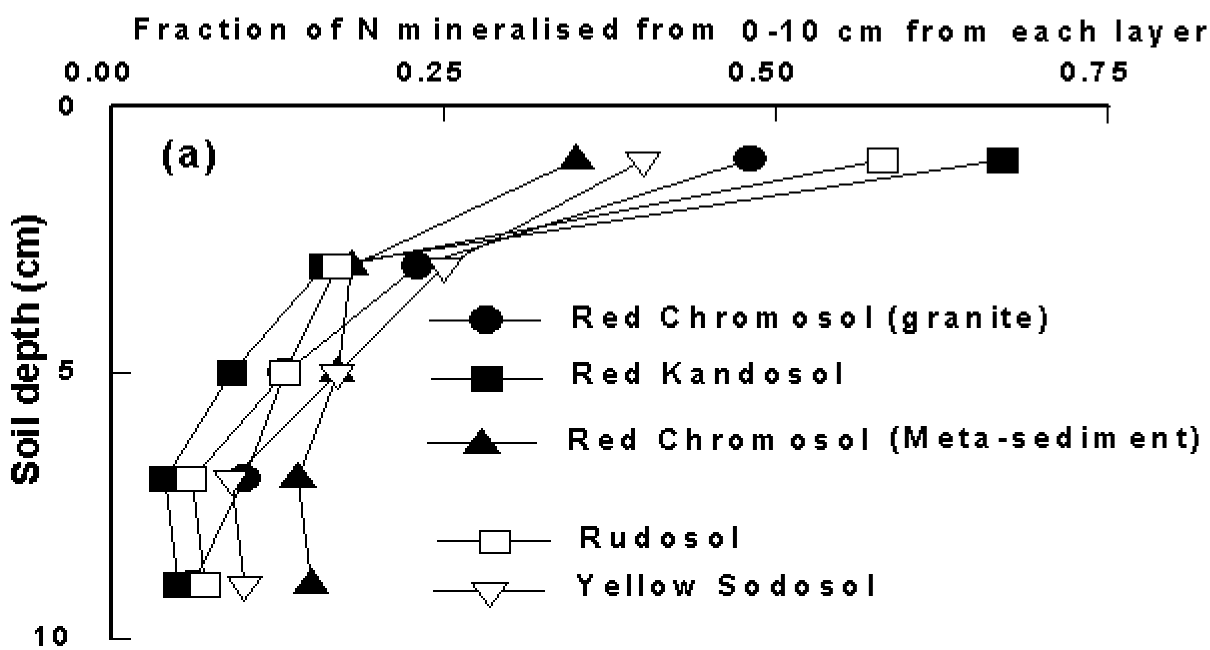

Figure 1a

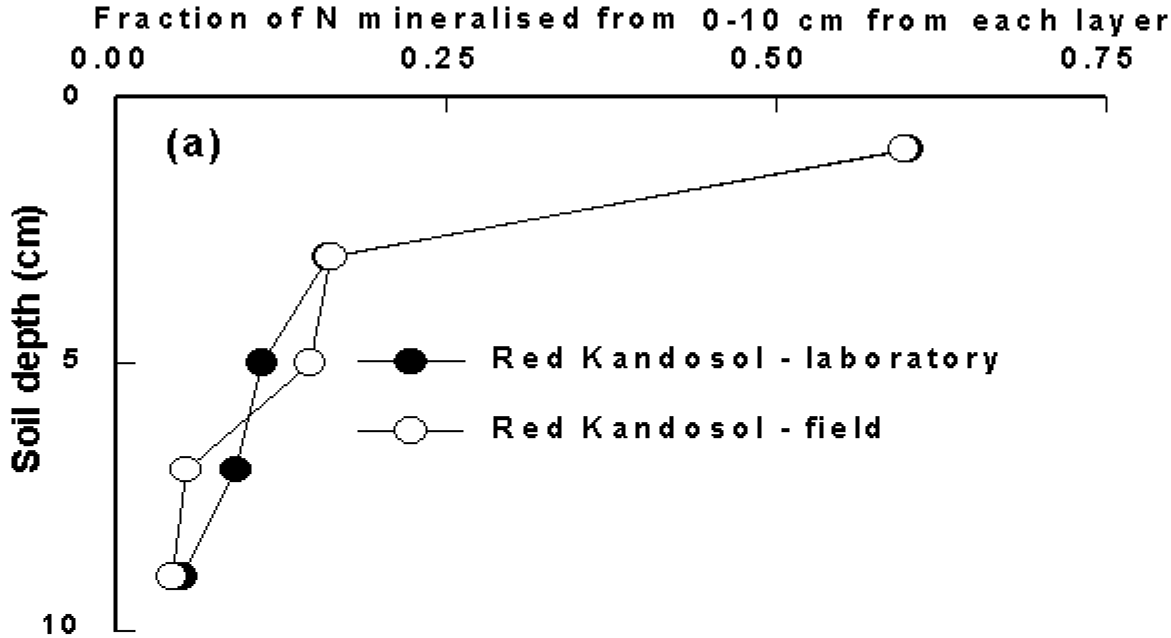

Figure 1b

In laboratory studies, an average of 50 % of mineral N produced in the top 10 cm of soil was released from the surface 2 cm in a range of soils sampled from under pasture (Fig. 1a). The contribution of each layer decreased with depth until an average of less than 17% was produced in soil from depths between 6 -10 cm. In the one soil from under a wheat crop which had been established with minimum tillage, 60% of mineral N originated from the surface 2 cm with less than 13% being produced below 6 cm (Fig. 1b).

Confidence in these estimates was increased by the observation that the distribution in mineralisation with depth was almost identical for both field and laboratory estimates under a wheat crop (Fig. 1b).

Factors influencing N mineralisation

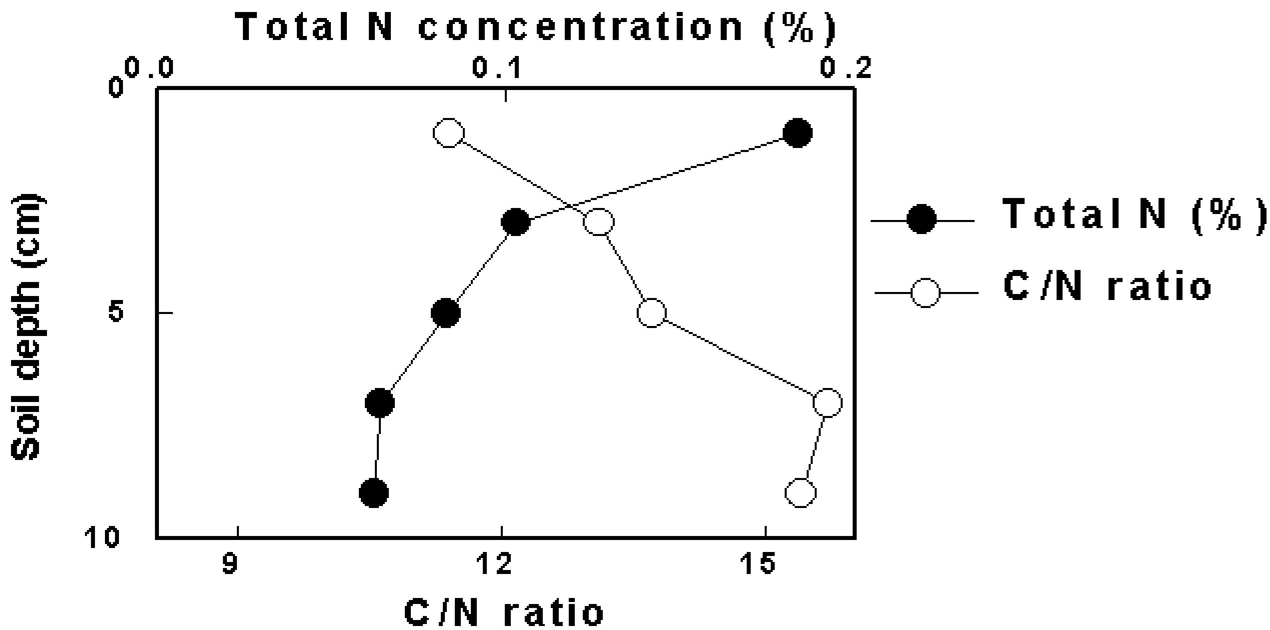

Figure 2

The concentration of the substrate for mineralisation (organic N) decreases with depth through both crop (3) and pasture soils (4, 6). Fig. 2 gives an example of data for a cropped soil.

Not only does the substrate concentration decrease but the C/N ratio increased from 11 in the 0-2 cm layer to over 15 below 6 cm in this soil. The increase in C/N ratio with depth indicates that the availability of the organic N to decomposition decreases with depth. In the selection of soils studied by Young *et al.* (6) the correlation between mineralisation and C/N ratio was not significant as the ratio either changed little with depth or the changes were small. However the percentage of total N mineralised decreased with depth.

The pH decreased through this depth interval but Young *et al.* (6) found that N mineralisation was not correlated with pH. This was attributed to the net tolerance of the diverse microbial population to pH variations.

Nitrification

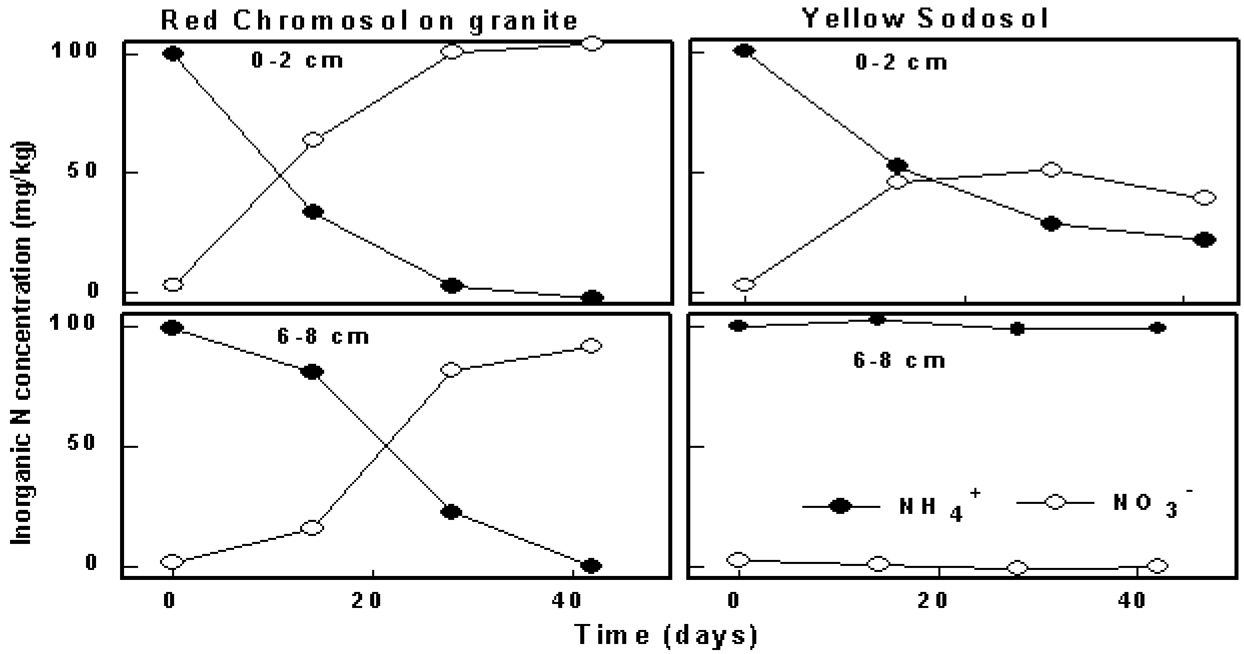

Figure 3

Nitrification rate was investigated in laboratory studies using soil collected from under both crop and pasture. In both studies NH_{4+} was added and accumulation of NO_{3-} measured. Fig, 3 reports the extent of nitrification in two contrasting pasture soils (6). Nitrification was rapid in the surface layer of the Red Chromosol being near complete in 30 days while in the deeper layer it was delayed but was almost complete in 42 days. In contrast, NH_{4+} had not been completely nitrified at 42 days in the surface layer of the Yellow Sodosol and no nitrification had occurred in the soil sampled from the depth of 6-8 cm.

Under field conditions in a Red Chromosol from under a wheat crop, NH_{4+} did not accumulate at any stage of plant growth suggesting that any NH_{4+} formed had been nitrified (3). However, in laboratory experi-ments using the soil from the same field, there was evidence that nitrification of added NH_{4+} was enhanced by lime addition to soil from 8-10 cm and to a much lesser extent to soil from the 0-2 cm layer (Table 1).

Factors influencing nitrification

Soil pH is a major factor controlling chemautotrophic nitrification. In the pasture soils studied, nitrification was highly correlated with soil pH ($r^2 = 0.79$, $P<0.01$).? Soil pH also decreased with depth throughout the surface 10 cm (2, 6). In the cropped soil pH decreased from 5.7 to 4.3 between 0-2 and the 8-10 cm interval (3). This observation combined with the lime effects reported in Table 1, suggest that pH was a major cause of the slow rate of nitrification below 6 cm. Other factors such as low microbial numbers and nutrient supply were investigated but were not found to be the cause of low nitrification rates below 6 cm.

Implications

These results confirm that the majority of plant available N is released in the surface few centimetres of soil. These layers are exposed to extremes of drying and temperature, both of which are likely to influence the rates of mineralisation. It seems plausable that the quantity of N mineralised under these conditions would be less than where the source of the plant available N was more evenly spread through the surface 10 cm of soil.

The impact of soil erosion on soil fertility in general and supply of plant available N in particular has long been recognised. However these findings indicate that loss of the surface few centimetres of soil will decrease the supply of N to crops and pastures. These data help to explain the observations of Aveyard (1) where loss of a few millimetres of soil at Wagga Wagga resulted an average of 47 % grain yield reduction.

In cropping soils it is clear that the rate of nitrification is less below a depth of 6 cm in soil which has not been inverted through cultivation. As most losses of N fert-iliser are associated with the nitrate form, this observat-ion suggests that deeper placement of ammonium based fertiliser may reduce the rate of nitrification and thus improve crop recovery of N fertilisers.

An indirect effect of the observation that the pH decreases rapidly through the surface 10 cm of soil would be on the estimation of the rates of acidification. Even if there was not net acidification by agricultural practices, soils which had the surface 1 to 2 cm removed by erosion would be soil tested and interpreted as having become more acidic in the surface 10 cm.

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