

Reactions of Urea in Four Contrasting Waikato Soils

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Introduction

Nitrogen (N)-based fertiliser use on intensively grazed pastoral areas has increased dramatically in New Zealand in an attempt to increase pasture production (Ledgard *et al.*, 1996). It is common for dairy farmers in the Waikato region to apply up to 200 kg N ha⁻¹ yr⁻¹ as urea. However, the effects of the increased urea use on soil properties in the region, and the receiving environment, is not well understood.

It has been well established in the past that urea hydrolyses rapidly in soils to form ammonium, which may then either be volatilised or converted to nitrate, and also that the rate of these reactions is dependent on many factors such as soil type and climate. The Waikato region has a wide range of soil types, particularly allophanic soils which are derived from volcanic alluvium and tephra and peat soils. Although variation in urea reactions has been well established for many soil types, there is a paucity of information in the literature on reactions of urea in soils derived from volcanic parent materials or organic substrates. The aim of this

research, therefore, is to improve our understanding of how urea reacts in common soils of the Waikato region.

Methodology

Small, undisturbed soil cores (100 mm diameter x 20 mm depth) were collected from soils in the Waikato region that are commonly grazed for dairy production. Two of the soils were formed from volcanic alluvium on the Waikato plains (Horotiu silt loam, Typic Orthic Allophanic Soil; and Te Kowhai silt loam, Typic Orthic Gley Soil), another was an organic soil from the lowlands (Motumaoho silty peat, Acid Humic Organic Soil) and the other soil was derived from airfall tephra on rolling hills (Ohaupo silt loam, Typic Orthic Allophanic Soil). Soils were moistened to 80% field capacity and had granulated K-Rich Urea (Petrochem Ltd.) applied to the cores at rates of 0, 50 and 100 kg N ha⁻¹ (equivalent to 0-200 kg urea ha⁻¹). The cores were incubated at 20°C for up to 24 days in sealed plastic bags to prevent drying. After time periods of 0.5, 1, 2, 3, 6, 12 and 24 days, three replicate cores were removed, thoroughly mixed and extracted using 2M KC1/PMA for analysis of urea-N, ammonium-N and nitrate-N by auto-analysis.

Results

Urea hydrolysed rapidly in all soil types with negligible amounts remaining in the soil after 1-2 days (Figure 1). The amount of urea remaining in all soils was dependent on the rate of urea application. For example, increasing urea application from 50 to 100 kg N ha⁻¹ resulted in a two-fold increase in the concentration of urea remaining in the soil in the first two days of incubation (data not presented). Differences also existed in the rates of reaction between the different soil types, with slower hydrolysis in the Te Kowhai silt loam than in the other soils (Figure 1).

Ammonium concentrations increased rapidly following the application of urea to the cores. Large concentrations were apparent within 0.5 days and gradually increased, peaking after one day (Figure 2). The concentration of ammonium formed was affected by both the soil type and the rate of application (Table 1).

The appearance of nitrate, as a result of urea application, was generally slower than ammonium. For example, in the Te Kowhai soil, large nitrate concentrations were not observed until one day following urea application and maximum concentrations were not observed until 12 days (Figure 2).

Table 1. Concentration of NH₄-N (µg g⁻¹) in the soil after incubation with urea applied at rates of 50 and 100 kg N ha⁻¹

Soils	2 Days		6 Days		12 Days	
	50 kg N ha ⁻¹	100 kg N ha ⁻¹	50 kg N ha ⁻¹	100 kg N ha ⁻¹	50 kg N ha ⁻¹	100 kg N ha ⁻¹
Te Kowhai	286	510	55	480	35	118
Horotiu	183	145	139	311	0	92
Ohaupo	356	576	0	234	39	430
Motumaoho	340	631	253	543	70	604

Discussion

The results indicate that urea hydrolysed rapidly in the four Waikato soils, although some differences were apparent between the different soil types. The rapid hydrolysis within 24 hours generally observed in the Waikato soils is consistent with previous reports of urea hydrolysis elsewhere (Rachhpal-Singh and Nye 1984a; O'Toole *et al.* 1985; Black *et al.* 1987; Whitehead and Raistrick 1990). The slower hydrolysis of urea was slower in the Te Kowhai soil, than in the other soils, may be due to less enzyme activity occurring naturally in the soil as a result of it's anaerobic environment.

The appearance of nitrate and ammonium in all the soils was rapid. Differences in the concentrations of ammonium and nitrate between soil types and application rates are attributed to differences in microbial activity between the soils. It is commonly accepted that the addition of N-based fertilisers, particularly urea, increases the amount of ammonium and nitrate in the soil (Rachhpal-Singh and Nye 1984b; San 1986; Ledgard *et al.* 1996)

These results have implications for the continued management of soils in the Waikato region. For example, if heavy rainfall or irrigation was to occur within 1 to 3 weeks of urea application when maximum nitrate concentrations occur, the likelihood of nitrate leaching would be enhanced. In addition the amount of nitrate formed is directly related to the urea application rate, and indicates that the timing and rate of urea application should be planned to meet plant demands.

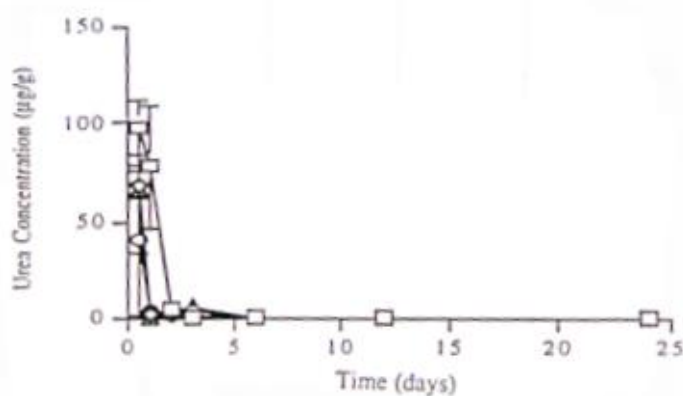


Fig. 1. Concentration of urea-N remaining in the soil after differing periods of incubation following application of 50 kg N ha⁻¹ in Te Kowhai (□), Horotiu (◇), Ohaupo (O) and Motumaoho (Δ) soils

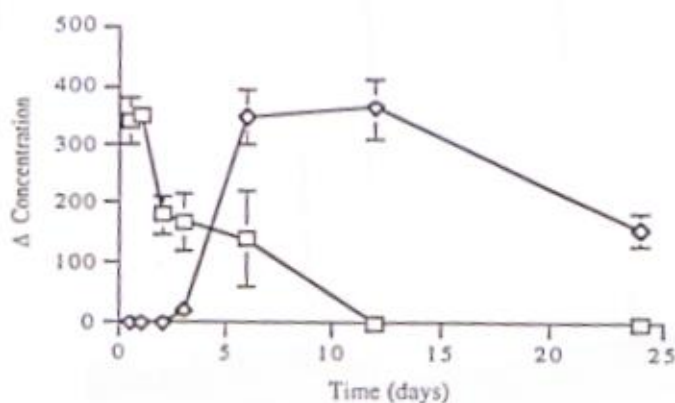


Fig. 2. Increase in NO₃-N (□) and NH₄-N (◇) concentrations (µg g⁻¹) following urea application (50 kg N ha⁻¹) in the Horotiu soil. Results calculated by subtracting control from treatment concentrations.

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