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**A description of the
soil potassium fertility
of steepland pastures in
the southern North
Island of New Zealand.**

**A thesis presented in partial fulfilment of the requirements
for the degree of Doctor of Philosophy in Soil Science at
Massey University.**

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Abstract

The pattern of soil K fertility was investigated in two typical steepland pastures, located in the southern North Island of New Zealand. The parent materials of soils in this area are predominantly derived from sedimentary rocks. The soils have medium to high K reserves, and K fertilisers are not normally applied to the areas of steepland pasture. The study sites are part of well-established mixed stock grazing farms and have received regular aerial topdressing with superphosphate for at least 30 years. Grazing animals in steepland tend to favour the flatter areas, which are mainly on the crests of the ridges, and to spend relatively short periods of time grazing the steep slopes. Concerns have arisen as to the development of K deficiencies on the steep slopes, as stock are expected to graze these areas, and then to excrete most of the K ingested in the herbage onto the flatter areas.

Two surveys were made of the K fertility patterns in two steepland paddocks. The first study was made over one paddock, by collecting soil samples along vectors of random direction, from points that were between 0.25 m and 25 m apart. The second survey targeted the main trends, sampling at regular intervals along the ridge crests and down the transects of the main slopes, at two paddocks. The tests on the soil samples included exchangeable K (Quick test K), acid extractable K and the difference between the two factors, which was thought to provide a measure of plant available nonexchangeable K (Step K).

The Quick test K values in one pasture alone ranged from 0.07 to 1.34 mg K/g soil, which was a range between very low and extremely high values for New Zealand soils. There was a similar wide range of values for other parameters. The frequency distributions of the soil test values were skewed, so that the arithmetic mean of the results was higher than 60-70% of the values. Spatial variability was at a maximum at a sampling distance of 0.25 m. The results indicated that the bulking of soil samples was a poor practise when sampling for exchangeable and plant available nonexchangeable K at these sites.

Some relationships could be discerned between the soil K fertility patterns and the position of the topsoil in a steepland landscape, despite the high spatial variability. On the steep slopes, the Step K value of a soil was related to the soil moisture pattern, as determined by aspect and water seeps, and also to the pattern of the soil parent materials. Quick test K had no similar relationship to position in the landscape on the steep slopes. The spatial variability of both tests increased as the ground slope decreased. The mean and variability of Quick test K increased sharply on both well drained shoulder slopes and ridge-tops that were animal campsites. In contrast, the mean and variability of Step K increased markedly only on the well drained ridge-top campsites. The different behaviour of cattle and sheep, the relatively large amounts of K deposited in excreta compared to P, and the slower rate of breakdown and dispersal of excreta in drier conditions, were all thought to contribute to these effects.

The mineralogy of the topsoils at the two sites was also investigated. The clay mineralogy was dominated by a complex of 2:1 layer silicates, accompanied by lesser quantities of quartz, feldspars and kandites. The topsoils formed a sequence, which ranged from a 2:1 layer silicate clay complex that was dominated by mica and interlayered mica smectite (MS), to a 2:1 layer silicate clay complex that was dominated by vermiculite and hydroxy interlayered vermiculite (HIV).

There was a very strong relationship between the Step K value and the mica content of a soil on the steep slopes. The relationship indicated that the dominance of either mica and MS, or vermiculite and HIV, in the clay fraction of a soil on the steep slopes depended on the original composition of the soil parent materials, the age of the soil profile, and the soil moisture conditions. On the shoulder slope and ridge-tops, there was a similar range of clay mineralogy, but Step K value now had a poor relationship to the mica content. This effect was mainly associated with soils under the well drained animal campsites, which had a distinctive mica and irregularly interstratified MS dominated clay mineralogy. The results were consistent with a reversal of the 2:1 layer silicate weathering processes under well drained animal campsites.

Concentrations of total K and P were investigated in the topsoils of the two steepland pastures. The average difference between the total P of slope and ridge-top samples was about 200 kg P/ha, indicating a relatively small accumulation of P on the ridge-

tops after many years of aerial topdressing and grazing. The expected accompanying increase in total K was not found. The marked effect of animal transfer processes on the plant available chemistry and mineralogy of the well drained ridge-top soils was thought to be a disproportionate indicator of the relatively small extent of total nutrient accumulation that appeared to have occurred on the ridge-top campsites.

The plant response to K fertiliser was measured at the two steepland pastures sites. No K uptake response or growth response was identified at either site, despite low exchangeable K values in some areas and a low K content in some of the pasture samples, even after fertiliser was applied. In contrast, an exhaustive pot trial, using a selection of soils from the two sites, revealed a considerable range in the ability of the soils to supply K.

Cation and anion concentrations were measured in the leachates of “stove pipe” soil cores collected from the ridge-tops and steep slopes. K concentration in the leachates of soil from the steep slopes were relatively low and reasonably consistent over time, compared to the Ca and Mg concentrations that were more sensitive to changes in the ionic strength. K concentration in the leachate of soils from different ridge-top locations varied markedly between the different locations. The increased leaching of K under animal campsites was identified as a significant loss mechanism for the K that is transferred to these areas. However, it was thought that an exact quantification of this process would be difficult, because the spatial variability of the concentration of K leaching from the topsoil into the subsoil under campsites was expected to be even higher than the spatial variability of exchangeable K in these soils.

In conclusion, animal transfer losses of K from the steep slopes to the flatter areas at these sites appeared to be in the low range for New Zealand steepland pastures. No significant depletion of the K fertility appeared to have developed on the steep slopes, although the measurements were confounded by the very high degree of spatial variability found in all aspects of the K fertility patterns. The current conventional practice of not applying K fertiliser to these and similar sites was thought to be sustainable.

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