MOISTURE STRESS IN HILL COUNTRY PASTURES OF NEW ZEALAND

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ABSTRACT
Moisture stress is a recognised factor in the persistence of desirable pasture species of naturalised hill country pastures of New Zealand. Two variables in a soil water balance model are examined here for their contribution to maintaining plant cover. Soil water infiltration is not a limiting factor even though these hill country soils will respond to lime and this response is believed to be due to its effect on the physical properties of the soil. However, the effect of microtopography and wind direction does reduce soil water input.

KEYWORDS
Moisture stress, infiltration, sorptivity, rainfall, microtopography

INTRODUCTION

Moisture stress is believed to play a significant role in the poor persistence of hill country pasture species in a climate that may be described as summer moist. The naturalised pastures of North Island, New Zealand, are a mosaic of species whose distribution has been attributed to the impact of grazing and nutrient redistribution (Rumball & Ester, 1968) and moisture redistribution (Lambert *et al*, 1984). An intuitive explanation is that species are associated with a runoff/runon phenomena which creates micro-environments.

To test this hypothesis soil moisture and rainfall were measured over a three year period. A soil moisture balance was unable to account for the measured soil moisture which was consistently drier than the model predicted. This study explores two possible explanation. Firstly; infiltration of water into the soil may be restricting soil moisture. Zhou *et al*. (1993) showed a significant pasture response to lime that was attributed to a higher level of soil moisture measured in the treated plots at this site. Similar responses to lime have been reported by Jackson & Gillingham (1985) and they claimed that the effect was due to the lime alleviating water repellency of hill soils. Secondly; the precipitation, measured in a vertically mounted standard rain gauge, may be over estimating inputs into the model.

METHOD

The site was a sunny northerly aspect on a Halcombe steepland soil (slope > 30½) with a pH range of 5.2-5.4. 2000 kg/ha of lime was applied in May, 1992 as part of a Molybdenum/lime trial. Two 46 mm diameter cores were taken from each plot to a depth of 50 mm. Pasture remnants were cut from the cores but surface organic matter retained. The cores were air dried for 10 days. Water sorptivities were measured, using a fine sand as a contact medium. The same cores were then dried in a forced draught oven without heat for five days before 95% ethanol sorptivity measurements were made.

Rainfall was measured with five gauges, one set vertically and one each at the four points of the compass set at 45½ from the vertical. The gauges were mounted 1.2 m above the plots. Rainfall was recorded for a two year period.

RESULTS AND DISCUSSION

There was a significant (P > 0.02) response to lime in the water sorptivity (Table 1). However the high rates of water absorption, about 2 mm/minute for the control and 3.5 mm/minute for the lime treatment, mean that these differences are unlikely to have any impact on the soil water balance.

The mean repellency index, measured as the water sorptivity divided by the ethanol sorptivity times 1.9 (Tillman et al. 1989), was 3.7 (range 2.4 - 7.3). Wallis *et al* (1991) showed that a repellency index of this magnitude was common and the improved soil moisture in response to lime must be due to improved soil structure. Changes in soil properties may be reflected in the distribution of water in the soil profile. Soil water data taken in December, 1992 using the TDR with 20 cm probes was re-analysed for variability (Table 2). The limed plots were wetter (P > 0.01) but their coefficient of variation (CV) was lower, implying a more even wetting of the soil. The measurements were made in a rough grid pattern to cover the plots and so are not amenable to pattern analysis. The scale of heterogeneity must be somewhere between a few centimetres to a metre.

The results from the rain gauge array are hard to interpret but large differences were measured. The rain vector would result from wind flow and the settling velocity due to gravity. Although the wind would move round the rain gauges the inertia of the rain drops would carry them into the gauge. A two year average indicated that rain fell from a compass bearing of 212½ (range 181½ → 236½) and some 17½ (range 42½ → -2½) off vertical. This represents a reduction in measured rainfall input of about 75% (range 44% → 100%) to a North facing slope of 30½. This reduced input would account for the missing water in the water balance. The site was in an East/West valley which would have funnelled the rain bearing south-westerly winds. The effect of microtopography on soil water input could be a factor in explaining the soil micro-environments and pasture species mosaic found on New Zealand hill pastures.

CONCLUSION

There is no evidence for soil water repellency to explain observed difference in soil water between limed and un-limed plots. The most likely explanation is for improved soil structure in the limed plots. Weather patterns that influence the direction of rainfall can affect the role that microtopography plays in species distribution.

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Table 1

The water sorptivity of hill soils under two lime treatments. ($ms^{-1/2}$).

Control	0.80
Lime	1.46
Pooled SDev	0.49

Table 2

Soil moisture levels (%) and coefficient of variation (%) in the limed and control plots.

Treatment	Nos: Obs	Soil moisture m3/m3)	CV
Control	40	22.0	29.4
Limed	40	24.6	20.6