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**The Influence of Pastoral Fallow on Hill Country Pastures,  
Emphasising White Clover Growth Behaviour**

**A thesis presented  
in partial fulfilment of the requirements  
for the degree of Doctor of Philosophy in Plant Science  
at Massey University, New Zealand**

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**1997**

## DECLARATION

The studies presented in this thesis were completed by the author whilst a postgraduate student in the Department of Plant Science, Massey University, Palmerston North, New Zealand. This is all my own work and the views presented are mine alone. Any assistance received is acknowledged in the thesis. All references cited are included in the bibliography.

I certify that the substance of the thesis has not been already submitted for any degree and is not being currently submitted for any other degree. I certify that to the best of my knowledge any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.



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## ABSTRACT

Appropriate pre-sowing methods for oversowing new plant germplasm and the presence of productive legume are of key importance to development of New Zealand hill country. A pastoral fallow, which involves not defoliating pasture for a period generally from spring to autumn, has profound influence on plant and soil, and creates a potentially favourable environment for introducing improved germplasm. A series of field and glasshouse experiments examined the response of pasture structure, soil properties and natural reseeding to pastoral fallow, and the post-fallowing effects on white clover (*Trifolium repens* L.) and pasture growth in moist North Island hill country, New Zealand.

Pastoral fallowing effectively reduced the plant population density and altered the structure of a hill sward. A seven-month (October - May) pastoral fallow dramatically decreased the densities of grass tillers by 72%, white clover growing points by 87% and other species by 87%. The decline in tiller density by pastoral fallow was enhanced on a shady, south facing aspect. Root growth and distribution was altered by pastoral fallowing and there was significantly less root biomass at 0 - 50 mm depth of soil in the fallowed than the grazed sward. Decreased plant density during pastoral fallowing was attributed to above-ground biomass accumulation which altered sward structure, leading to inter-plant competition and mortality by self-thinning and completion of the life circle of some matured plants.

Pastoral fallowing significantly improved soil physical properties. Compared with the grazed treatment, pastoral fallow increased soil air permeability at 500 mm tension by 38%, saturated hydraulic conductivity by 26%, unsaturated hydraulic conductivity at 20 mm tension by 56% and soil moisture by 10 - 15%, and reduced soil bulk density by 11% at the end of an October - May pastoral fallow. Pastoral fallow had little effect on the concentration of most

nutrients in soil both at the end of fallowing and two to three years after fallowing.

A spring - autumn pastoral fallow increased the viable grass, legume and weed seed population by 51-160%, compared with the grazed control. The variation in viable seed population during the fallow followed a predictable pattern, which could be used to manipulate natural reseeding in practice. Regression analysis revealed that the patterns of cumulative seedling appearance followed a modified negative exponential function. Partial differentiation of this function derived a germination rate curve on which a two-pool (rapidly germinable pool and base pool) model was developed to quantitatively describe the seed dynamics of soil viable seed reserves.

Short-duration (partial) pastoral fallow had a marked effect on plant population density and natural reseeding. Pastoral fallows starting from December, January and February or March with nitrogen addition and ending in June considerably reduced plant population density. Most partial pastoral fallows also considerably reduced viable seed population of all plant species, except for December to June fallow which had a higher viable grass seed population than the grazed sward.

Pastoral fallowing increased dispersion of white clover stolons by internode elongation. At the conclusion of a pastoral fallow, the clover stolons initiated branching, and grasses initiated tillering. Their growth and competition resulted in a greater grass growth rate in the first two years after fallowing, and a greater white clover yield and content with an increase in clover patch density and size 3 - 4 years post-fallowing, compared with the grazed pastures.

**Key words:** hill pasture, pastoral fallow, plant population density, soil physical properties, stolon, sward structure, viable seed population, white clover.

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## PREFACE

Pastoral fallow - what is it? Why do you do it? How does it affect plant and soil in a hill pasture? When and how long do you do it? What are its short- and long-term effects on pasture species composition and yield? This thesis provides answers to these questions.

This thesis is based on a series of papers that have been prepared for publication, preceded by Introduction and Objectives (Chapter 1) and General Literature Review (Chapter 2), and succeeded by General Discussion and Conclusion (Chapter 8). A series of experiments were undertaken to quantify the effects of pastoral fallow on pasture plant, soil, natural reseeding and white clover growth behaviour in a naturalised hill pasture at the AgResearch Hill Country Research Station, 'Ballantrae' near Palmerston North, New Zealand.

Chapters 3 and 4 are based on a field experiment where a fallowing treatment was imposed from October 1993 to May 1994. Chapter 3 describes changes in plant population density and sward structure of a mixed-species hill pasture during the experiment, and the application of self-thinning rule to the fallowed treatments. Chapter 4 compares plant root growth and soil physical and chemical properties between fallowed and grazed swards. To describe the long-term effects of pastoral fallow on soil chemical characteristics, soil samples were taken and analysed from plots with previous fallowing history (Experiment 2 in Chapter 4).

Since the seed production by pasture plants and resultant drop in plant/tiller density by fallowing were considered as an opportunity to reseed, identification and numbers of seedlings germinating from turf plugs kept in a glasshouse were recorded to examine the effect of pastoral fallow on the potential to naturally reseed. Chapter 5 gives quantitative descriptions on 1)

the patterns of seed germination for various plant species after fallowed and grazed treatments (Experiment 1 in the chapter), and 2) variation of natural reseeding during the October 1993 to May 1994 pastoral fallow (Experiment 2 in the chapter).

Chapter 6 describes the impact of timing and duration of pastoral fallow and nitrogen fertiliser on plant density, sward structure, natural reseeding and white clover growth in a field experiment from December 1994 to September 1995. Seed germination from soil plugs held over seven-months in a glasshouse was recorded to estimate the capacity of natural reseeding in various treatments following the field experiment.

Chapter 7 describes the short- and long-term effects of pastoral fallow on herbage production and plant population density with emphasis on white clover growth and distribution. The results of the experiment examining the short-term effect of pastoral fallow, based on the experiment described in Chapter 3, are presented as Experiment 1 in this chapter. The long-term effect of pastoral fallow was investigated on plots with a series of fallowing history (Experiment 2 in the Chapter).

Since the individual papers are self-contained with their reference listing, separate reference listing is given for Chapters 1, 2 and 3 as well. The context and/or structure of individual papers have been modified to fit into chapters, which are integrated into the thesis.