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**LEGUME ABUNDANCE IN NEW ZEALAND SUMMER-MOIST
AND SUMMER-DRY HILL COUNTRY PASTURES**

A thesis presented in partial fulfilment of the requirements

of the degree of

Doctor of Philosophy (PhD)



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*To Paulina, for her love, patience and constant support
To Nicolas, Benjamin, Vicente and 'Chumi', my dear boys
To my dear father who inspired me
To my mother for her unconditional love*

... 'Immer wenn Du meinst, es geht nicht mehr, kommt von irgendwo ein Lichtlein her...'

ABSTRACT

The introduction of legumes has been a central factor in hill country pasture improvement in New Zealand since they are able to fix atmospheric nitrogen to contribute to pasture production and also improve pasture quality. However, at present legume content of hill swards has dropped to generally very low levels which will likely affect medium-long term sustainability of these pastoral ecosystems. This thesis is focussed on determining the relative importance of management and environmental factors that affect legume abundance in hill country swards. A series of field experiments were undertaken between May 2000 and April 2002 in contrasting summer-moist (Ballantrae; 40°19'S, 175°50'E) and summer-dry (Waipawa; 40°00'S, 176°23'E) hill country areas, including north aspects and south aspects at Waipawa, to evaluate the relative impacts of cutting height (targets of 3 or 7 cm), grass suppression by application of selective herbicide, soil-P status (high or low), autumn nitrogen application (0 or 50 kg N/ha), defoliation management (cutting, and rotational grazing with sheep), on legume abundance. A glasshouse experiment involved the effects of companion grasses and defoliation on individual white clover and subterranean clover plants grown in pots.

The suppression of grass competition caused the most marked changes in short-term sward composition, with an increase in legume abundance at all sites. Increasing soil-P status increased legume abundance, especially where white clover was present as a major botanical component. Altering pasture cutting height or applying nitrogen in the autumn had comparatively minor effects on legume abundance. Defoliation management (i.e. rotational grazing with sheep compared with cutting) played a secondary role in affecting legume abundance of swards, at least in the short term.

Residual effects of grass suppression resulted in an increase in legume abundance, which persisted for at least one year after treatment and affected legume species composition in the drier Waipawa north aspect. Pastures in the summer-moist areas showed a high degree of resilience and reverted quickly to the original grass dominance. Inter-annual and site contrasts in soil moisture patterns highlighted the relevance of soil moisture as a key factor in determining legume abundance and production, mainly in the summer-dry areas. In the glasshouse trial, severe defoliation had very strong effects, reducing plant size, leaf area, vegetative stem development and branching of individual legume plants. Moreover, root competition from grasses was seen to significantly limit clover shoot growth, this being more important than the shading effect.

From these experiments, it is suggested that the relative importance of factors affecting legume abundance in hill pastures is: soil moisture (if limiting, e.g. summer-dry hill country) > grass suppression > soil-P status > defoliation management > nitrogen application. However, some of these factors have been noted to interact, and relationships can acquire higher levels of complexity.

This study highlighted the relative importance of factors that influence legume abundance of hill country swards and showed that pasture composition can be dramatically modified and legume content increased, but also that these changes can be short-lived. Summer-dry hill country pastures strongly rely on highly variable non-manageable seasonal and inter-annual soil moisture profiles, and legume abundance is difficult to predict and less stable in time than in summer-moist conditions. However, a high potential of legume abundance is achievable with adequate soil moisture in summer, even at low soil-P status. In these dryland areas, the combination of limiting soil moisture, close-to-ground defoliation, and selective grazing, is likely to severely limit white clover growth and spread, and be aggravated by low soil-P status, as well as subterranean clover growth and seed set, therefore compromising legume abundance in the following season.

High tiller population density, combined with a high frequency and intensity of legume defoliation, will put legumes under stress from severe grass competition, ultimately affecting legume abundance. This is likely to be the case for many intensively set stocked hill country systems managed with sheep.

Keywords: Hill country pastures, legume abundance, white clover, subterranean clover, soil moisture, summer-dry, summer-moist, grass suppression, competition, cutting, rotational grazing, soil phosphorus status, nitrogen fertiliser.

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