PHYSIOLOGICAL AND MORPHOLOGICAL RESPONSES OF TALL FESCUE (*Festuca arundinacea* SCHREB.) AND PERENNIAL RYEGRASS (*Lolium perenne* L.) TO DEFOLIATION

A thesis presented
in partial fulfilment of the requirements
for the degree of Doctor of Philosophy (Ph. D.) in
Pasture Ecology and Physiology
Department of Plant Science
Massey University

HOSSEIN TAVAKOLI

1993

Massey University Library
Thesis Copyright Form

Title of thesis: Physiological and Morphological responses of tall fescue and perennial ryegrass to defoliation

(1) (a) I give permission for my thesis to be made available to readers in Massey University Library under conditions determined by the Librarian.

(b) I do not wish my thesis to be made available to readers without my written consent for .6 months.

(2) (a) I agree that my thesis, or a copy, may be sent to another institution under conditions determined by the Librarian.

(b) I do not wish my thesis, or a copy, to be sent to another institution without my written consent for 6. months.

(3) (a) I agree that my thesis may be copied for Library use.

(b) I do not wish my thesis to be copied for Library use for .6. months.

Signed H. Tavakoli TAVAKOLI

Date 3/12/93

The copyright of this thesis belongs to the author. Readers must sign their name in the space below to show that they recognise this. They are asked to add their permanent address.

NAME AND ADDRESS DATE

ABSTRACT

Tall fescue (*Festuca arundinacea* Schreb.) has been suggested as an alternative to perennial ryegrass, particularly in conditions of moisture limitation, but there is little comparative information on the plant characteristics influencing regrowth in the two species, particularly under continuous stocking. The objectives of this study were to :i) examine the response of tall fescue to continuous stocking in terms of tillering activity, leaf growth and competition, and ii) determine which physiological or morphological factors are important in influencing regrowth after defoliation, using perennial ryegrass as a reference standard. Experiments were undertaken in field, glasshouse and controlled environment conditions.

In the field sown swards of tall fescue (*Festuca arundinacea* Schreb. cv. 'Grassland Roa') and white clover (*Trifolium repens* L. cv. 'Grassland Tahora'), with volunteer grasses mainly consisting of perennial ryegrass (*Lolium perenne* L. cv. 'Grassland Nui') were continuously stocked with varying numbers of sheep to maintain sward surface heights 90-100 mm (Lax, L), 50-60 mm (Medium, M) and 30-40 mm (Hard, H). Measurements were made on areas with and without clover by removal of white clover with clopyralid. Tiller population density, tiller weight, and leaf growth and productivity of tall fescue were all reduced under hard grazing. Tall fescue was susceptible to competition from companion species, particularly perennial ryegrass, and tended to be replaced by other species under hard grazing.

Under glasshouse conditions individual plants of tall fescue and perennial ryegrass were defoliated to stubble heights of 100 mm (Lax, L), 60 mm (Medium, M), 30 mm (Hard1, H1) and 30 mm (Hard2, H2) 9 times with 5 day intervals over a period of 45 days. Treatments L, M, and H1 were initiated at an average of 11 tillers per plant for each species; treatment H2 commenced at 6 tillers per plant. Both species showed sensitivity to severe cutting treatments by reduction in tiller number, tiller weight, leaf growth and less shoot and root growth. Tall fescue showed lower leaf growth, tillering activity and herbage harvested per plant than perennial regress, but it produced larger tillers.

The comparative response of tall fescue and perennial ryegrass to leaf defoliation was studied under controlled environment conditions at both the vegetative and reproductive stages of growth. The oldest leaf lamina was defoliated regularly to maintain four, three, two or only one live leaf per tiller for six or seven leaf appearance intervals. In both species repeated removal of older leaves had little effect on tiller production, tiller weight, leaf growth rate and consequently total accumulated shoot and root weight, and mean shoot and root relative growth rates. Removal of all fully expanded leaves resulted in significant reduction in the above components, though leaf elongation rate was little affected. Leaves were shorter, narrower and lighter under hard defoliation, but leaf appearance rate was not affected. Hard defoliation affected tall fescue tiller weight more than perennial ryegrass. Water soluble carbohydrate concentrations in stem bases of plants decreased with increasing severity of defoliation especially for tall fescue. Leaf photosynthetic capacity per unit area was not influenced by defoliation intensity, but photosynthetic capacity per unit leaf weight increased under hard defoliation. Hard defoliation decreased the proportion of root mass to shoot mass, and increased the proportion of leaf mass to shoot mass. Plants showed relatively similar sensitivity to defoliation at vegetative and reproductive phases of growth. At both phases tall fescue again produced larger tillers with longer leaves and had a longer leaf life-span than perennial ryegrass, but it had lower leaf growth and appearance, and produced fewer tillers per plant. Photosynthetic activity per unit leaf area was similar for the two species, but tall fescue often had lower photosynthetic rate per unit leaf weight than perennial ryegrass.

In conclusion, hard defoliation intensity reduced both tiller population density and tiller weight and consequently decreased pasture regrowth through a reduction in LAI, life-span of leaf area, photosynthetic efficiency, and shortage of carbohydrate reserves. The factors that resulted in the regrowth of tall fescue being less responsive to hard defoliation than perennial ryegrass were slower leaf turnover, slower leaf appearance rate, lower tillering capacity and longer leaf life-span. These resulted in lack of plasticity in tiller population density of tall fescue in response to hard defoliation.

ACKNOWLEDGEMENTS

First of all praise to almighty God for giving me the ability to learn.

I would like to express my deepest gratitude to my chief supervisor Dr Peter David Kemp and co-supervisor Professor John Hodgson for their patience, enthusiastic encouragement, guidance and close supervision throughout the course of this study. I was provided with friendly answers at any time that I needed their help.

I am deeply indebted to Dr Cory Matthew for his generosity in time and useful advice made available to me through his "open door".

Thanks are extended to Drs I.L. Gordon and S. Ghaneshanandam for statistical advice, Drs A.C.P. Chu, I. Valentine and K. Harrington (from Department of Plant Science), Mr J. Brock and Drs D. Hume, and D.F. Chapman (from AgResearch CRI), Drs D.W. Fountain, C.A. Cornford and Professor R.G. Thomas (from Department of Plant Biology) for their helpful comments; Messrs B. Butler, for his tissue turnover programme, T. Lynch and M.A. Osborne for their technical field assistance, R. Johstone, C. Forbes, G. Russell, for assisting in the preparation of the Growth Cabinets and Glasshouse facilities, the staff of Horticulture CRI for organising the Climate room, Mrs S. Cleland for her technical assistance; and Mrs J. Cave, and especially, Ms C. McKenzie and Ms Frith Brown for their technical and organisational assistance made available to me at any time.

The friendly environment provided by my fellow graduate students in Plant Science Department is much appreciated, especially the friendship of Mr Manzoor-ul-Haque Awan which will never be forgotten.

The presence of all Iranian postgraduate students and their families in Palmerston North made my family and I feel at home. It is my pleasure to thank and wish them a happy and prosperous future.

I would like to express my sincere thanks to the Ministry of Jahad-e-Sazandegi and Ministry of Culture and Higher Education of IRAN, for awarding me the scholarship to undertake this study.

Special thanks to my wife Tayebeh for her patience, considerable encouragement and assistance in a number of ways, but especially undertaking my own duty to educate our children. The patience of my son Mosslem and my daughter Maryam and their positive responses to education provided for them made me happy and encouraged me to cope with difficulties. Finally the forbearance and encouragement of my other family members and friends is deeply appreciated.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 3:

CHAPTER 5 (Vegetative stage- experiment 2)

LIST OF FIGURES

LIST OF PLATES