



THE EFFECTS OF CEREAL STRAW RESIDUES ON GERMINATION,
EMERGENCE AND PRODUCTIVITY OF ANNUAL MEDICS

by

Paul Edward Quigley, B. Agr. Sc. (Melb.)

A thesis submitted to the University of Adelaide
in fulfilment of the requirements for
the degree of Doctor of Philosophy

Department of Agronomy
Waite Agricultural Research Institute
The University of Adelaide

July, 1988

TABLE OF CONTENTS

	<u>Page No.</u>
ABSTRACT	(v)
STATEMENT	(vii)
ACKNOWLEDGEMENTS	(viii)
LIST OF FIGURES	(ix)
LIST OF TABLES	(xi)
LIST OF PLATES	(xiv)
LIST OF APPENDICES	(xv)
1 GENERAL INTRODUCTION	1
2 LITERATURE REVIEW	9
2.1 Hard-seededness in annual pasture legumes	9
2.1.1 The nature of hard-seededness	9
2.1.2 Physiology of breakdown of seed impermeability	12
2.1.3 Environmental and genetic effects	14
2.2 Effects of leachates from straw on plant growth and development	21
2.2.1 The phytotoxic effects of crop residues on plants	21
2.2.2 The nature of phytotoxins	26
2.2.3 Physiological response of plants to phytotoxins	31
2.2.4 Enhanced pathogenesis caused by crop residues	33
2.2.5 Variation in phytotoxicity caused by plant and environmental factors	35
2.3 Physical effects of crop residues on seedling development	38
2.3.1 Alteration of microclimate	38
2.3.2 Mechanical impedance to emerging seedlings	40
2.4 Discussion and conclusions	42
3 THE EFFECTS OF CEREAL STRAW RESIDUES ON REGENERATION AND PRODUCTIVITY OF ANNUAL MEDIC PASTURES IN SOUTH AUSTRALIA	43
3.1 Introduction	43
3.2 Field Survey 1: Arthurton district, Yorke Peninsula, 1983	43
3.2.1 Materials and methods	44
3.2.2 Results	48
3.2.3 Discussion	55
3.3 Field Survey 2: Mallala district, Adelaide Plains, 1984	57
3.3.1 Materials and methods	57
3.3.2 Results	59
3.3.3 Discussion	60

3.4	Field Survey 3: Mallala district, Adelaide Plains, 1985	76
3.4.1	Materials and methods	76
3.4.2	Results	79
3.4.3	Discussion	81
3.5	Field Experiment 1: Effects of straw concentration on natural regeneration and productivity of an annual medic pasture at Two Wells	95
3.5.1	Materials and methods	95
3.5.2	Results	97
3.5.3	Discussion	101
3.6	Field Experiment 2: Effects of straw concentration on emergence of annual medic seedlings in the field at Reeves Plains	116
3.6.1	Materials and methods	117
3.6.2	Results	119
3.6.3	Discussion	122
3.7	Conclusions	123
4	THE INFLUENCE OF CROP RESIDUES ON BREAKDOWN OF HARD-SEEDEDNESS IN ANNUAL MEDICS	126
4.1	Introduction	126
4.2	Field Experiment 3: The influence of cereal stubble and seed depth in soil on breakdown of seed impermeability in annual medics	126
4.2.1	Materials and methods	127
4.2.2	Results	134
4.2.3	Discussion	143
4.3	Field Survey 4: The influence of cereal stubble and seed depth in soil on the incidence of seed impermeability in annual medics	145
4.3.1	Materials and methods	145
4.3.2	Results	147
4.3.3	Discussion	151
4.4	Conclusions	153
5	STUDIES ON PHYTOTOXINS LIBERATED FROM STRAW, USING ANNUAL MEDIC BIOASSAYS	154
5.1	Introduction	154
5.2	Bioassay methodology	156
5.3	Experimental	158
5.3.1	Inhibition of medic seed germination by leachates from cereal straw	158
5.3.2	Effects leachates from cereal species and cultivars on medics	161
5.3.3	Medic cultivar responses to leachates from straw of Weeah and Galleon barley	166
5.3.4	Assessment of leachates progressively obtained from fresh straw	171
5.3.5	Effects of straw weathering in the field on phytotoxicity of leachates	174
5.3.6	Microbiological filtration of leachates and its effect on phytotoxicity	177
5.3.7	Leachates applied to seedlings in a soil system (I)	181
5.3.8	Leachates applied to seedlings in a soil system (II)	184
5.4	Discussion and conclusions	186

6	PHYSICAL IMPEDANCE OF EMERGENCE OF MEDIC SEEDLINGS AND ENHANCED PATHOGENESIS CAUSED BY STRAW MULCHES	192
6.1	Introduction	192
6.2	Pot culture methodology	194
6.3	Experimental	195
6.3.1	Effects of a cereal chaff mulch and a plastic mulch on emergence and establishment of seedlings of <i>Medicago truncatula</i>	195
6.3.2	Interaction between seed depth in the soil and chaff mulch concentration	199
6.3.3	Mathematical relationships between chaff concentration and medic seedling establishment and dry matter production	206
6.3.4	Early development patterns of seedling mortality as affected by mulch concentration	210
6.3.5	Comparisons of straw, chaff and chemically-inert mulches	213
6.3.6	Effects of soil sterilization on seedling responses to chaff mulch	218
6.4	Discussion and conclusions	220
7	GENERAL DISCUSSION AND CONCLUSIONS	223
7.1	The relationship between annual medic productivity and the concentration of straw residue in the field	223
7.2	Changes in hard-seededness of medic influenced by straw residues	225
7.3	Allelopathic effects of cereal straw residues	227
7.4	Enhanced pathogenesis associated with straw residues	229
7.5	Future studies warranted	230
8	APPENDICES	232
9	BIBLIOGRAPHY	234

ABSTRACT

The studies reported in this thesis investigated the effects of cereal straw residues on plant density and dry matter production of annual medics (*Medicago* spp.). Straw residues, concentrated in walker rows, are known to be detrimental to medic productivity but there have been no previous reports quantifying these effects and little effort has been made to understand the relative importance of alternative biological mechanisms which could be responsible for retardation of medic growth.

To determine the form of the relationship between straw residues and annual medics, surveys were conducted in cereal stubble paddocks located on the Adelaide Plains and Yorke Peninsula Regions of South Australia. Increasing concentrations of straw were consistently associated with reductions in medic plant density. In most cases these plant densities were well below that considered desirable for optimum herbage production, consequently there were concomitant reductions in medic dry matter production per unit area. Comparison of alternative mathematical functions fitted to the data indicated that an exponential decay was most appropriate. Theoretical considerations of this particular function support it as the best choice.

Results from Field Experiment 1 in which seven straw concentrations were compared for their effects on medic emergence confirmed the findings from the surveys. Medic seed production, however, was generally not affected by the straw concentration. Field Experiment 2 showed that emergence of seedlings, from scarified seed, could be slowed by high concentrations of ground-straw mulch but mulch concentrations up to a maximum of 8000 kg/ha did not impair final seedling establishment. The field work provided indirect and direct evidence that high concentrations of straw residues were associated with increased intensity of pathogen attack of medic seedlings which resulted in depressed establishment of medics: however, the incidence of pathogen attack was erratic. Alternative means of managing straw residues are discussed.

Field Experiment 3 demonstrated that straw residues could substantially retard breakdown of medic hard-seededness over summer/autumn (the proportion of permeable

seed was 35 per cent less than that in an unmulched treatment) and this could exacerbate insulation effects caused by deep burial of medic seed in soil. This difference in permeability would almost certainly have been larger if the experiment had commenced earlier so its duration more closely approximated natural field conditions.

Large differences in the proportion of hard seed associated with concentrations of straw residues were also clearly shown when medic seed was collected from three field sites shortly before the seasonal break in 1986. It was concluded that the degree of thermal insulation of annual medic seed during summer/autumn is a major determinant of the density of naturally-regenerating medic seedlings. Long term effects of different thermal regimes on medic hard-seededness were detected similar to effects found on subterranean clover seed reported by other researchers.

Bioassay experiments were used to investigate possible allelopathic reactions by medic seedlings to leachates from cereal straw. Both the genotype of medic and of straw were important in determining the extent that radicle elongation was inhibited i.e. the typical seedling response. These effects were moderated by weathering of the straw or by microbial activity, either in the bioassay or where seedlings were grown in soil. There was little effect of leachates on the germination percentage of *M. truncatula* seed. Ecological implications of these results are discussed and phytotoxicity from straw residues is discounted as a factor contributing to differences in medic plant density as observed in the field investigations.

In pot experiments, increasing concentrations of macerated straw mulch were associated with a greater incidence of seedling mortality caused by *Pythium* fungi. In comparison, neither a plastic mulch nor addition of leachate from straw affected medic seedling establishment. It was concluded that the straw provided a source of nutrients which enabled rapid multiplication of the pathogen. Variation in microclimate and edaphic factors would account for the erratic frequency of pathogen attack on medic seedlings in the field.