

**PHOSPHORUS AND MANGANESE
SEED COATINGS FOR CROP
GROWTH AND YIELD**

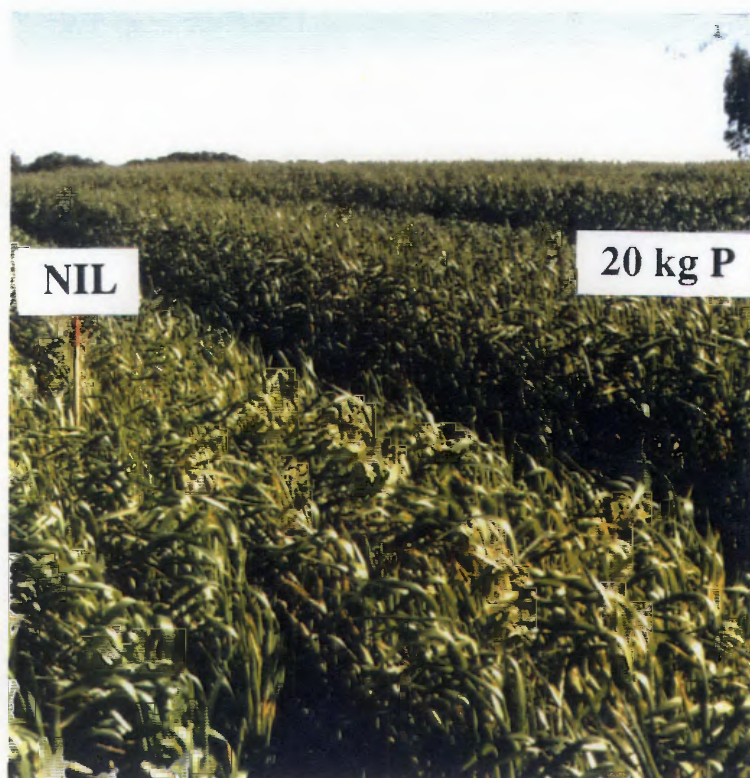
Julie Sandra Ascher

**Department of Agronomy and
Soil Science
University of New England
Armidale, N.S.W.**

**Thesis submitted for the Degree of Doctor of
Philosophy**

February 1994

(a)



(b)

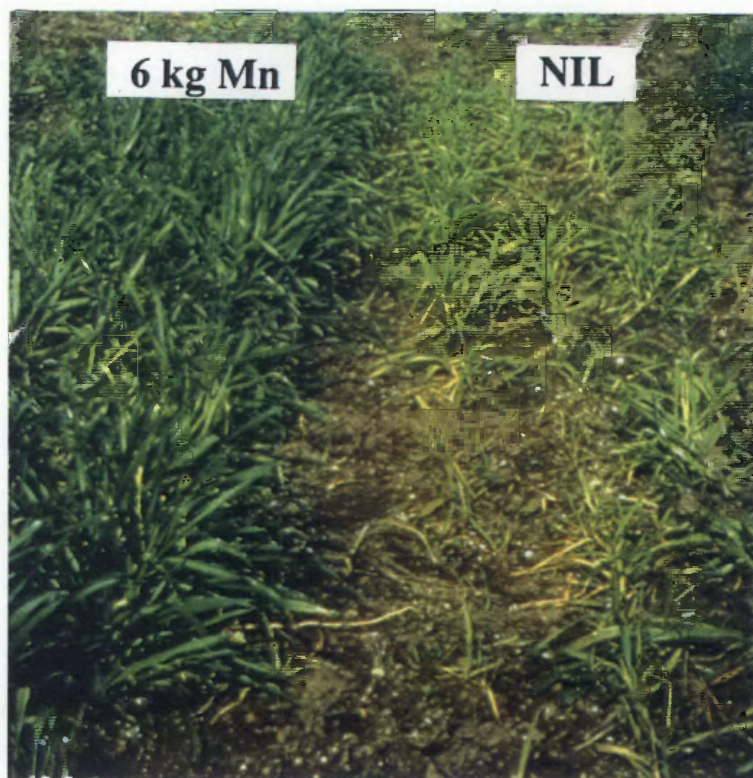


Plate 1. Field response to applied fertiliser (a) wheat sown without or with phosphorus at Mintaro, South Australia, photo courtesy of B. Bull HiFert Pty. Ltd. (b) Galleon barley sown with and without manganese at Marion Bay, South Australia.

DEDICATION

To my parents

Florence Maud and Gilbert Saul Ascher

and my husband

Peter Anthony Edward Ellis

for their love, support, patience and understanding.

TABLE OF CONTENTS

DEDICATION	ii
TABLE OF CONTENTS	iii
LIST OF FIGURES	v
LIST OF TABLES	vii
LIST OF PLATES	ix
LIST OF APPENDICES	x
ABSTRACT	xi
ACKNOWLEDGMENTS	xiii
DECLARATION	xiv
 Chapter 1. INTRODUCTION	 1
1.1 Fertiliser usage in Australian cropping systems	1
1.2 Fertiliser Efficiency	2
1.3 Details of the project	4
 Chapter 2. REVIEW OF THE LITERATURE	 6
2.1 Introduction	6
2.2 Phosphorus	10
2.2.1 Phosphorus chemistry and fertiliser availability	11
2.2.2 Methods of phosphorus application	13
Broadcast vs banded applications	13
Phosphorus Content of Seed	18
Seed Soaking	21
Seed Coating	22
2.2.3 Fertiliser injury	24
Damage by phosphatic fertilisers	25
Damage caused by other fertilisers	26
Effect of application method	28
Mechanisms involved	28
Toxicity	29
Osmotic stress	29
Induced deficiency	31
Environmental effects	32
Species tolerance	33
2.3 Manganese	35
2.3.1 Manganese chemistry/fertiliser availability	36
2.3.2 Methods of Mn fertiliser application	38
Broadcast vs Banded Applications	40
Foliar Applications of Mn	41
Manganese Content of Seed	42
Seed Soaking	44
Seed Coating	47
2.3.3 Fertiliser Injury associated with Mn fertilisers	49
2.4 Nutrient seed coating	50
2.4.1 Macronutrient Coatings	51
2.4.2 Micronutrient Coatings	51
2.4.3 Efficiency of seed coating compared with conventional fertiliser applications	52
2.4.4 Tolerance to injury	54
2.4.5 Combination Coatings	55
2.5 Conclusions The potential of nutrient seed coating for cropping	56

Chapter 3 FERTILISER INJURY DUE TO PHOSPHORUS SEED COATINGS INFLUENCE OF SPECIES, SOIL MOISTURE AND TEXTURE.	59
3.1 Introduction	59
3.2 Materials and methods	60
3.3 Results	62
3.4 Discussion	67
Chapter 4. COMPARISON OF THE EFFICIENCY OF DRILLED AND SEED COATING APPLICATIONS OF PHOSPHORUS	71
4.1 Introduction	71
4.2 Materials and methods	73
4.3 Results	77
4.4 Discussion	85
Chapter 5. MANGANESE SEED COATING AS A FERTILISER STRATEGY FOR BARLEY AND WHEAT	91
5.1 Introduction	91
5.2 Sources of Mn and additives for seed coating	92
5.2.1 Introduction	92
5.2.2 Materials and Methods	93
5.2.3. Results	97
5.3 Efficacy of Mn seed coating compared with current Mn fertiliser strategies.	107
5.3.1 Introduction	107
5.3.2 Materials and Methods	107
5.3.3 Results	109
5.4 Discussion	120
Chapter 6. ENHANCED MANGANESE CONTENT OF BARLEY SEED	124
6.1 Introduction	124
6.2 Fertiliser strategies to enhance manganese content of barley seeds.	126
6.2.1 Materials and methods	126
6.2.2 Results	126
6.3 Comparison of seed Mn content and Mn seed coating for barley	128
6.3.1 Materials and methods	128
6.3.2 Results	131
6.4 Discussion	139
Chapter 7. GENERAL DISCUSSION	143
BIBLIOGRAPHY	150
Appendix 1	I
Appendix 2	VI

LIST OF FIGURES

Figure	Page
2.1 Effect of seed P concentration on dry matter yield of Jacup wheat sown in pots.	20
3.1 Effect of three rates of MCP seed coating on wheat emergence.	63
3.2 Final emergence of eight crop species coated with an inert coating or with MCP at three rates.	63
3.3 Effect of soil moisture and seed coating on emergence of coated seeds for 4 species.	65
3.4 Effect of amount of MCP coating applied per seed on final emergence for eight crop species.	68
4.1 Effect of increasing P applied as seed coating or as drilled application on shoot dry matter yield of (a) barley, (b) oats (c) wheat and (d) sorghum.	79
4.2 Effect of method and rate of P application on the P uptake of shoots of (a) barley, (b) oats (c) wheat and (d) sorghum.	80
4.3 Critical curves for P in shoots of (a) barley, (b) oats (c) wheat at early tillering 30 days after sowing and (d) sorghum 20 days after sowing.	81
4.4 Effect of P application on (a) vegetative yield 74 DAS and (b) grain yield of barley grown in the field experiment at Gunnedah.	84
5.1 The effect of seed coating treatments on (a) dry matter production and (b) Mn uptake at early tillering 40 DAS and (c) dry matter production and (d) Mn uptake at mid tillering 75 DAS.	98
5.2 Effect of nutrient fungicide combinations on (a) dry matter yield, (b) Mn uptake of whole shoots 63 DAS, (c) grain yield at maturity without a foliar Mn application and (d) grain yield with foliar applied Mn.	101
5.3 Dry matter production at (a) early tillering 66 DAS and (b) grain yield of Galleon barley coated with combinations of nutrients and fungicides.	102
5.4 (a) Dry matter production at early tillering and (b) Grain yield of Galleon barley coated with six potential seed coating materials applied at two rates.	106

5.5	Effect of method and rate of Mn application on shoot dry matter yield of Galleon barley (a) sampled 74 DAS (b) sampled 140 DAS without foliar applied Mn (c) sampled 140 DAS with foliar applied Mn (d) grain yield without foliar Mn and (e) grain yield with foliar Mn.	110
5.6	Effect of method and rate of Mn application on shoot dry matter and grain yield of Galleon barley grown in Experiment 6 Marion Bay 1990.	112
5.7	Effect of fertiliser rate and application on dry matter yield for two sampling times and grain yield of wheat grown at Marion Bay.	114
5.8	Efficacy of Mn seed coating in the presence of two background fertilisers DAP and MAP+urea .	118
5.9	Effect of Mn fertiliser treatments on grain yield of Galleon barley grown at Marion Bay 1992 (a) without fungicide and (b) with Mancozeb fungicide	120
6.1	(a) Vegetative Yield and (b) Mn uptake at tillering of Galleon barley grown from seed with different Mn concentrations selected from various sites and grown at Marion Bay in 1989.	132
6.2	(a) Dry matter production at 69 DAS and (b) grain yield of Schooner barley grown from seed with different Mn concentrations at Marion Bay 1990	134
6.3	(a) Dry matter production at 35 DAS, (b) Mn uptake at 35 DAS and (c) Grain yield of Skiff barley grown from seed with different Mn concentrations at Marion Bay 1991	137
6.4	Yield and Mn uptake of Skiff barley grown from seed with different Mn concentrations and treated with nil, seed coated or drilled applications of Mn at Marion Bay 1992.	138

LIST OF TABLES

Table	Page
1.1 Fertiliser usage in Australia.	2
2.1 Critical levels of nutrients in seeds for normal seedling growth.	43
3.1 Parameters of Mitscherlich curves fitted to the emergence data for four coating treatments of sorghum sown in 4 soils of different texture.	66
3.2 Parameters of Mitscherlich curves fitted to the emergence data for four coating treatments of wheat sown in 4 soils of different texture.	66
4.1 Rates of drilled P found to give equivalent growth to that of the coated P applications in the glasshouse study.	81
4.2 Comparison of parameters used in this study and Scott <i>et al.</i> (1991).	83
4.3 Plant establishment, vegetative yield, P concentration, P uptake and grain yield due to seed coating with P compared to conventional drilled P applications. Monarto, S.A. 1991.	85
5.1 Treatment description and application rates for seed dressings used in Experiment 1, Marion Bay, 1989.	94
5.2 Treatment description and application rates of coating materials used in Experiment 2, Marion Bay 1990.	95
5.3 Treatment description and application rates of coating materials used in Experiment 3, Marion Bay 1991.	96
5.4 Treatment description and application rates used in Experiment 4.	97
5.5 Effect of seed treatment on nutrient content of whole shoots 40 and 75 DAS, and visual assesment of plants 75 DAS.	99
5.6 Dry matter yield and nutrient concentration in whole shoots at early tillering and grain yield at maturity of Galleon barley coated with nutrient and fungicide treatments. Experiment 2, Marion Bay 1990.	100
5.7 Plant establishment, vegetative yield, Mn concentration and Mn uptake at early tillering 66 DAS and grain yield at maturity of Galleon barley coated with different combinations of nutrients and fungicides. Experiment 3, Marion Bay 1991.	103
5.8 Visual assessment, vegetative yield, Mn concentration, Mn uptake at early tillering and grain yield at maturity of Galleon barley coated with different Mn sources grown at Marion Bay S.A. 1991 (Experiment 4).	105

5.9	Rates of application of Mn to the soil (kg ha^{-1}) in each of the 5 field experiments, Marion Bay, S.A.	108
5.10	The effect of Mn fertiliser treatments on Mn concentration and uptake of Galleon barley grown in Experiment 5 at Marion Bay 1989.	109
5.11	Effect of rate and method of application of Mn fertiliser on establishment, development and yield of Galleon barley grown in Experiment 8 at Marion Bay in 1991.	116
5.12	Effect of Mn treatments on concentration of nutrients in YEBs and on grain yield of Galleon barley Marion Bay 1992 (Experiment 9).	119
6.1	The effect of foliar Mn applications during grain filling on the Mn concentration and content of barley grain produced at Marion Bay.	127
6.2	Seed source, nutrient concentration and seed weight for barley seeds used in Experiments 1 to 4.	129
6.3	Effect of seed source on dry matter yield, Mn uptake and grain yield of Schooner barley grown with and without seed-coated Mn.	133
6.4	Vegetative yield and Mn uptake of Galleon barley seedlings grown from seed with varying levels of seed Mn with and without Mn fertiliser applied to the seed or soil at sowing at Marion Bay 1991.	136
6.5	Visual score, number of plants established/metre of row, number of tillers per plant and plant height of barley seedlings, 35 DAS, grown from varying levels of seed Mn with and without Mn fertiliser applied to the seed or soil at sowing at Marion Bay 1991.	136
6.6	Effect of Seed Mn content and Mn application on dry matter production and Mn uptake of Skiff barley. Experiment 4, 1992.	139

LIST OF PLATES

Plate		Page
1.	Field response to applied fertiliser (a) wheat sown without or with phosphorus at Mintaro, South Australia, photo courtesy of Barry Bull, HiFert Pty. Ltd. (b) Galleon barley sown with and without manganese at Marion Bay.	i
2.	Response of crops to coated and drilled applications of P, grown in pot experiment 1. (a) wheat, (b) barley, (c) oats and (d) sorghum. Rate of P applied is indicated above the plant (kg ha^{-1}). Method of application is indicated below the plant; C = coat, D = drill.	78
3.	Response of Galleon barley to Mn fertilisers applied as seed coating materials in Experiment 1 at Marion Bay 1991.	104
4.	Layout of Experiment 8 at Marion Bay in 1991 showing treatment responses at tillering.	115
5.	Response of Galleon barley to coated and drilled applications of Mn at Marion Bay in Experiment 8, 1991.	117
6.	Skiff barley with varying content of seed Mn sown at Marion Bay in Experiment 3 1991.	135

LIST OF APPENDICES

Appendix	Page
1. Description of soils used in experiments	I
2. Monthly rainfall data, Marion Bay 1989-1992	VI

ABSTRACT

This thesis investigates seed coating as a method of improving the efficiency of fertiliser applications for phosphorus (P) and manganese (Mn) to crop species. Seed coating provides a great opportunity of placing precise amounts of nutrient in close proximity to the seed to enable immediate access to nutrients. However, this close contact of seed and fertiliser can be detrimental and both delay and reduce emergence. This is not a limitation to coating seeds with Mn it can however be a serious problem with P seed coating.

Three emergence studies were conducted to identify which species and soil conditions are conducive to P seed coating. Experiments were conducted in the field and in pots to assess the performance of P seed coatings compared with more conventional drilled applications of P. Coating wheat seed with P was more efficient than drilled applications of P when grown under controlled conditions and low light intensity. This result however, was not confirmed in the field where soil moisture was variable and coarse sandy soil resulted in injury during emergence.

Of several Mn fertilisers tested, Mn sulphate and Mn dextrolac were most effective as seed coating materials. Seed coating with Mn was more efficient than the more conventional drilled applications of granules of Mn oxysulphate but not more effective than drilled applications of Mn coated macronutrient fertiliser (when compared on the basis of yield per unit input of Mn). However on a cost basis Mn seed coating was more economic than drilled applications of Mn coated macronutrient fertiliser. Including Mancozeb in the coating further enhanced the performance of Mn coated barley seed.

Barley grown under conditions of acute Mn deficiency resulted in seed with low Mn content. Barley seed with high natural content of Mn significantly increased dry matter yield at Marion Bay except when seed from Marion Bay was resown there, the latter suggesting that other elements, possibly Zn and P, were also limiting. A strategy of post-anthesis foliar applications of Mn was developed so that farmers on soils acutely deficient in Mn could ensure grain being sown in the following year has adequate Mn content.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the involvement, friendship and support of my supervisors, Dr. Jim Scott, Dr. Robin Jessop and Dr. Robin Graham.

This thesis was supported in part by a grant from the Rural Credits Development Fund and a by grant from the Grains Research and Development Corporation.

The enthusiastic support and friendship of John McEvoy and his family, who not only provided land for the field work, but welcomed me into their home and were always ready to help is gratefully acknowledged. I would also like to thank Phil and Mal Heath for provision of land at Gunnedah, and Rob Theile for use of land at Monarto.

This work was undertaken part-time at two Universities, I thank the staff and students of both the Department of Agronomy and Soils at the University of New England and the Department of Plant Science at the Waite Agricultural Research Institute for their friendship, assistance and valuable discussions. In particular I am grateful to Laurie O'Donnell for help with the initial emergence experiments and to Leanne Lisle and Judy Gaudren for assistance with chemical analysis at UNE. Derek Cameron and Anne White for coating seeds and helping with computing at UNE. Teresa Fowles and Nick Robinson for the many tissue samples analysed by ICP at the Waite Institute. David Doyle and Rod Kingston NSW Agriculture for assistance with sowing and harvesting the field trial at Gunnedah and David Morris for assistance with field trials at Marion Bay. The field work could not have been completed without the help of Vale Pederson, Jenny Emery and Karl Weich in processing the many samples collected. I would also like to thank Ms Lynn Giles (Waite Institute) and Dr. Ian Davies (UNE) for advice with statistical analysis. Thanks are also due to Jo Seeton for comments on the thesis.

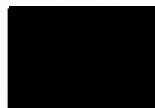
The fertilisers used throughout this project were specially formulated and donated by Hi Fert Pty. Ltd., I am grateful to Barry Bull for his guidance with fertiliser decisions and to the late Brian Barber for preparation of these products.

DECLARATION

I certify that this thesis contains no material which has been accepted for the award of any other degree in any University.

Any help received in the preparation of this thesis, and all sources used have been acknowledged.

I consent to this thesis being made available for photocopying and loan if applicable, if accepted for the award of the degree.

A solid black rectangular box used to redact the signature of the author.

Julie Sandra Ascher