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2003

Phosphorus influence on the response of pasture plants to salinity

Kanjanarat Cho-Ruk
University of Wollongong

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**PHOSPHORUS INFLUENCE ON THE RESPONSE OF PASTURE
PLANTS TO SALINITY**

A thesis submitted in fulfilment of the requirements for the award of the degree

DOCTOR OF PHILOSOPHY

From

**UNIVERSITY OF WOLLONGONG
AUSTRALIA**

BY

KANJANARAT CHO-RUK

ENVIRONMENTAL SCIENCE

DECEMBER 2003

CERTIFICATION

I, Kanjanarat Cho-Ruk, certify that this thesis is my own work and has not been submitted for acquiring qualifications at any other institutions. I also declare that the contents of this thesis are from my personal studies unless otherwise indicated or acknowledged. This thesis is submitted in fulfillment of the requirements for the award of Doctor of Philosophy, in Environmental Science Unit, University of Wollongong, Australia.

Kanjanarat Cho-Ruk

December 2003

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I dedicate this thesis to Arporn and Damri Cho-Ruk, my parents who gave me the inspiration and especially the encouragement to study for a Ph.D. The greatest

loss of my life happened during my study in Australia. This thesis is dedicated to my brother, Grich, in heaven. Thanks also go to my only sister, Jirapun, for everything she has done for my family when I was away from home to take the degrees and to come to Australia to support me when I was discouraged.

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ABSTRACT

Soil salinity is a growing global problem, as the presence of salts in soils is known to impact on the growth of various plants. One feasible means suggested for limiting the impacts of salinity is the use of nutrient fertilisers. This project was initiated to assess whether the use of phosphate fertiliser would benefit the growth of pasture plant species. The interaction of P and salinity in relation to the growth of pasture plants was studied using a series of experiments. The investigations included pot experiments, using sand cultures with salinity impositions, and natural saline soils in the greenhouse, plant nutrient uptake in saline conditions, by assessing tissue mineral contents. Soil P adsorption under saline conditions was also determined to assist in explaining the results of the pot experiments.

P adsorption isotherms were measured for 3 NSW soils in various concentrations of NaCl. Different methods of salt addition (direct addition of salt solution, salt incubated soils, and different periods of time of soil in contact with salt solution) were applied to the studied soils. Salt addition increased P adsorption significantly in all 3 soils. However, there was no significant difference in P adsorption when varying the concentrations of salt (0.003-0.12mol/L NaCl). Salinity increased P adsorption in soils but further increases in NaCl concentration did not increase P adsorption. Extended contact time between soils and NaCl solution appeared to reduce the overall P adsorption capacity in soils.

Plants from 5 pasture species were grown in pots with suboptimum, optimum, and high P levels in saline cultures to compare yields. Salinity affected plant seed germination in all species by reducing the numbers of sown seeds germinated and slowing the germination rate. At the highest salinity level used (12 dS/m), all seeds failed to germinate. Considering the germination rate, the salt tolerance ranked from

ryegrass, birdsfoot trefoil, orchard grass = red clover and white clover. Under normal experimental conditions in sand culture, 25 ppm P as NaH_2PO_4 solution was determined as the optimum P level for all pasture species. Insufficient and excessive levels of P caused injury in plants and affected yields and plant tissue mineral contents.

Ryegrass with various salinity treatments (0, 2, 4, 8 and 12 dS/m) showed that salinity reduced ryegrass yields significantly as the degree of salinity was increased despite the optimum P additions (25 ppm). Salinity impacts varied during the plant growth development. When plants grew older, their salt tolerance improved, and the plants showed more tolerance to salinity as they reached maturity. Salinity also reduced P uptake by ryegrass plants.

Plants responded positively up to certain limits to P additions (17 and 25 ppm) in non-saline treatments. In saline treatments, plants responded differently over the whole range of added P. Positive results were obtained when P was added up to 17 and 25 ppm. Further increases in added P did not increase plant yields; indeed, negative results or no change were obtained. Therefore, over a wide range of studied P, plants showed both positive and negative effects as well as no effect of P in saline conditions. Increasing added P increased P content in plant tissues. In all treatments where salinity was imposed, salinity increased Na and Cl contents in plant tissues. However, the effects of salinity on other mineral constituents were highly crop specific.

In a natural saline soil culture, there was no mass response of red clover and ryegrass yields to P additions. Increased P level in the treatments did not show any plant capacity to overcome the effect of salinity. Plants still showed symptoms of salinity injury, such as yellowing and leaf burn. Salinity therefore was the main

retarding factor. Increasing P fertilisation in a natural saline soil increased P content in plant tissues.

This current study indicates that the interactive effects between salinity and P depended on P range and salinity level. Plants responded differently over a wide range of P at low and medium levels of salinity. However, P additions at any concentration were not able to assist plants overcome the effects of salinity at extremely high saline conditions, as poor soil structure and plant physiological disorders limited plant responses to added P. Limiting the development of soil salinity is the major way to reduce its impact on crop production.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	Title Page	i
	Certification	ii
	Acknowledgeable	iii
	Abstract	v
	Table of Contents	viii
	List of Tables	xiv
	List of Figures	xvii
	List of Abbreviation and Symbols	xx
1	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Nature of the Problem and Background to the Study	2
	1.2.1 Types of Salinity	4
	1.3 Aims	11
	1.4 Thesis Outline	12
2	LITERATURE SURVEY	13
	2.1 Introduction	13
	2.2 Soil Salinity	13
	2.3 Australian Salt-Affected Lands	22
	2.3.1 Extent of Saline Soils	22
	2.3.2 Sources of Salts	29

2.4 Effects of Salinity on Plant Growth	32
2.4.1 Effects of Salts on Plant Absorption of Nutrients	32
2.4.2 Effects of Salts on Forms of Soil Nutrients	33
2.4.3 Effects of Salts on Plant Processes	34
2.4.4 Effects of Salts on Soil Microorganisms	
and their Activities	36
2.4.5 The Constraints Related to Soil Physical Conditions	37
2.4.6 Toxicity and Specific Ion Effects	37
2.5 Tolerance of Plants to Soil Salinity	45
2.6 Salinity and Fertility	50
2.6.1 Plant Mineral Tissue Contents	55
2.6.2 Plant Composition with High Salinity	58
2.7 P in Soils	59
2.8 Factors Affecting P Availability to Plants	61
2.9 P Problems in Soil Fertility	63
2.9.1 Forms of P in Soils	64
2.9.1.1 Organic P in Soils	64
2.9.1.2 Inorganic P in Soils	65
2.9.2 Effect of Organic and Inorganic P in Soils	66
2.10 P Fixation	66
2.10.1 Sorption Reactions	67
2.11 P Sorption Isotherm Equations	69
2.12 Factors Influencing P Sorption in Soils	72
2.12.1 Oxyhydroxide Content	73
2.12.2 Nature and the Quantity of Clay Present	73
2.12.3 pH	74
2.12.4 Extent of P Saturation	75
2.12.5 Organic Matter	76
2.12.6 Time	76
2.12.7 Temperature	77

2.12.8	Moisture Content	77
2.12.9	Effects of Salts and Ionic Strength	78
2.12.9.1	The Effect of Electrolyte Concentration on P Adsorption	78
2.12.9.2	The Effect of Cation Species on P Adsorption	81
2.13	P in Plants	84
2.13.1	P Deficiency Symptoms	85
2.14	Pasture Species Studied	87
2.14.1	Legumes	88
2.14.1.1	Red Clover	88
2.14.1.2	White Clover	89
2.14.1.3	Birdsfoot Trefoil	89
2.14.2	Grasses	90
2.14.2.1	Perennial Ryegrass	90
2.14.2.2	Orchard Grass	90
2.15	Summary of Literature Review	92
3	EXPERIMENTAL MATERIALS AND METHODS	95
3.1	Introduction	95
3.2	Soils Studied	96
3.2.1	Introduction	96
3.2.2	The Soils	96
3.2.3	Soil Profile Descriptions	96
3.2.4	Soil Sample Preparation	96
3.3	Instrumental Techniques	97
3.3.1	pH	97
3.3.2	Salinity	97
3.3.3	P Concentration in Solution	97
3.3.4	Weighing	97

3.3.5 Deionised Water	98
3.3.6 Harvesting of Plants from Pot Experiments	98
3.4 Salt Concentrations and Electrical Conductivity	98
3.5 P Adsorption Analysis	99
3.5.1 P Adsorption Isotherm Procedure	100
3.5.2 Salinity Effects on P Adsorption	102
3.5.2.1 Direct addition of Salt to P Sorption Solutions	102
3.5.2.2 Incubation of Soil with Salt at Field Capacity, Followed by Reaction with Added P	102
3.5.2.3 Incubation of Soil with Saline Solutions Followed by Reaction with Added P	102
3.6 Sand Preparation	103
3.7 Sand Electrical Conductivity, pH and Water Holding Capacity	103
3.8 Pasture Seed Germination Trials	104
3.9 Greenhouse	104
3.10 Pot Experiments	105
3.10.1 Determination of Optimal P Addition Rates for Pasture Species (High Range of P)	106
3.10.1.1 The Optimal P for Pasture Species Using Low P Concentrations	106
3.10.2 The Effect of Salinity at Optimal P in Ryegrass	108
3.10.3 The Effect of Varying P at Constant Salinity Levels on Pasture Species-Pot Experiment	109
3.10.4 Plant Growth in a Naturally Saline Soil with Varying P at Constant Salinity (DP2 Soil)	109
3.11 Plant Tissue Material Analysis	111
4 RESULTS AND DISCUSSION	114
4.1 Introduction	114
4.2 Salinity Effects on Soil P Adsorption	114

4.3 Sand Properties	129
4.4 Seed Germination	130
4.5 Assessment of Optimal P Addition Rates for the 5 Pasture Species	133
4.6 The Effect of Salinity on Growth of Ryegrass at Optimum P Conditions	155
4.7 Investigation of Salinity and P Interactions in Pot Experiments where 2 Salinity and 5 P Levels were Used	162
4.8 Plant Growth in a Naturally Saline Soil with Varying P at Constant Salinity (DP2 Soil)	176
4.9 Limitations of this Study	185
 5 CONCLUSIONS AND RECOMMENDATIONS	187
5.1 Introduction	187
5.2 Conclusion	187
5.3 Recommendations for Further Research	191
5.4 Saline Soil Management Regime	194
 REFERENCES	195
 APPENDICES	224
Appendix 1: Information of Measurement of Salinity and Salinity Units	224
- EC and EC _{1:5}	224
- Units Used to Measure Salinity	226
-Common Measurement Correlations to dS/m	227
Appendix 2: Detailed Information of Hoaglands Nutrient Solution and Solution	229
2.1 Nutrient Solution Preparation	229
2.2 P Application	230
2.2.1 Optimum P for Pot Experiment at High Range of P	230

2.2.2 Optimum P for Pot Experiment at Low Range of P	231
2.2.3 P Preparation at the Concentrations of 3, 10, 17, 25 and 35 ppm as $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$	232
2.2.4 P Application for Natural Saline Soil (DP2)	234
Appendix 3: Notes in the Soils Used in Laboratory and Pot Experiments	235
Appendix 4: P Adsorption Isotherms for DP1, JBU1 and TG1 Soils	244
4.1 P Isotherms of DP1, TG1, and JBU1 Soils with No Salt Addition	244
4.2 P Adsorption Isotherms for JBU1 Soil after Incubation with NaCl Salt at Various Amounts	245
4.3 P Adsorption Isotherms for JBU1 Soil with NaCl Solution Addition to Reaction Solution	248
4.4 P Adsorption Isotherms for DP1 Soil after Incubation with NaCl Salt at Various Amounts	249
4.5 P Adsorption Isotherms for DP1 Soil with NaCl Solution Addition to Reaction Solution	252
4.6 P Adsorption Isotherms for TG1 Soil after Incubation with NaCl Salt at Various Amounts	253
4.7 P Adsorption Isotherms for TG1 Soil with NaCl Solution Addition to Reaction Solution	256

LIST OF TABLES

TABLE NO.	TITLE	PAGE
1.1	Irrigated Land Damaged by Salinity	5
1.2	Global Estimate of Secondary Salinisation in the World	8
1.3	Area of Salt Affected Soils in Different Regions of the World	9
2.1	Classification of Salt-Affected Soils in the USA	14
2.2	Major Properties of Saline, Sodic and Waterlogged Soils Relevant to Plant Survival and Growth	20
2.3	Area of Land Affected by Dryland Salinity in Australia	28
2.4	A Comparison of Estimates Salinity Extent	30
2.5	The Relative Tolerance of Forage Crops to Salinity	48
2.6	The Summary of the Interaction Between Salinity and Fertility	51
2.7	Estimated Concentration of P in Soil Solution Associated with 75 and 95% of Maximum Yields of Selected Crops	85
2.8	EC Threshold and P Concentration Level in Soil Solution	91
3.1	Analytical Data for Reference Plant Tissue Sample (NIST) Standard Reference Material, 1515 Apple Leaves	112
3.2	Analytical Data for Reference Plant tissue Sample (NIST) Standard Reference Material, 1515 Apple Leaves (Continued)	113
4.1	P Maximum Adsorption for JBU1 Established from Langmuir Equation	123
4.2	P Maximum Adsorption for DP1 Established from Langmuir Equation	124
4.3	P Maximum Adsorption for TG1 Established from Langmuir Equation	125
4.4	Effect of NaCl Concentrations on Adsorption by Soils after 2 Different Shaking Periods	127

4.5	Sand Properties for Pot Experiments	129
4.6	Germination Rates of Pasture Plants at Different Salinity Levels	131
4.7	Mineral Compositions in Red Clover at Different Levels of P Addition	147
4.8	Mineral Compositions in Birdsfoot trefoil at Different Levels of P Addition	148
4.9	Mineral Compositions in Orchard Grass at Different Levels of P Addition	149
4.10	Mineral Compositions in Ryegrass at Different Levels of P Addition	150
4.11	Reference Selected Plant Tissue Mineral Contents in Sufficiency Ranges for Legumes, Orchard Grass and Ryegrass	151
4.12	Analytical Data for Sand Separates after Completion of Ryegrass Plant Growth Experiment (Low Range P)	154
4.13	Mineral Compositions in Ryegrass Grown under Optimum P and Different Salinity Conditions	158
4.14	Mineral Contents in Red Clover Grown at Different Levels of Salinity and P	165
4.15	Mineral Contents in Birdsfoot trefoil Grown at Different Levels of Salinity and P	167
4.16	Mineral Contents in Orchard Grass Grown at Different Levels of Salinity and P	169
4.17	Mineral Contents in Ryegrass Grown at Different Levels of Salinity and P	171
4.18	P and Na Contents in Red Clover and Ryegrass Tissues from Pot Conducted with Natural Saline Soil (DP2)	179
4.19	Ca and Mg Contents in Red Clover and Ryegrass Tissues from Pot Conducted with Natural Saline Soil (DP2)	179
4.20	K and S Contents in Red Clover and Ryegrass Tissues from Pot Conducted with Natural Saline Soil (DP2)	180
4.21	Al and Fe Contents in Red Clover and Ryegrass Tissues from Pot Conducted with Natural Saline Soil (DP2)	180
4.22	Mn and Cd Contents in Red Clover and Ryegrass Tissues from Pot Conducted with Natural Saline Soil (DP2)	180

4.23	Cu and Mo Contents in Red Clover and Ryegrass Tissues from Pot Conducted with Natural Saline Soil (DP2)	181
4.24	Co and Zn Contents in Red Clover and Ryegrass Tissues from Pot Conducted with Natural Saline Soil (DP2)	181
A1	P Levels at High Range of P Concentrations	231
A2	Low Ranges of P Solution Prepared by Using $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$	232
A3	Volumes of P and Salt Solutions for the Control Treatment (No Salt Added)	233
A4	Volumes of P and Salt Solutions for the Salt Treatment (4dS/m)	233
A5	Volumes of P Solution as KH_2PO_4 in Natural Saline Soil (DP2)	234
A6	Mineralogy of Soils Used	243
A7	Soil Properties of DP1, DP2, TG1 and JBU1	243

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Map of North Eastern Part of Thailand where Salt-Affected Areas are Found	3
1.2	The Salinity Regime	5
1.3	Types of Salinity	7
2.1	One Classification System for Saline, Sodic, and Alkaline-Sodic Soils	18
2.2	The Classification of Normal, Saline, Sodic and Saline-Sodic Soils in Relation to pH, EC, SAR, ESP and the Degree of Sensitivity of Plants to Salinity	19
2.3	Waterlogging in Soil Caused by Salinity	22
2.4	Soil Erosion Resulting from Soil Salinity	23
2.5	The Distribution of Normal, Saline, Saline-Sodic and Sodic Soils in Australia	24
2.6	Raising of Groundwater Table due to Land Clearing for Catchments	26
2.7	How Land Clearing Can Cause Salinity	27
2.8	The Relative Crop Yield in Relation to Soil Salinity for Plant-Tolerance Groupings of Maas and Hoffman	42
2.9	Salt Tolerances in Crops and Pasture Plants	49
2.10	Diagram of Yield and Nutrient Concentration	56
2.11	Yield or Growth in Response to Increasing Nutrient Concentration and Interpretation	57
2.12	P Cycle in Different Forms in Soils	63
2.13	Mechanism of P Adsorption to Al/Fe Oxyhydroxide Surface	68

2.14	Typical P Sorption Isotherm Plotting Between the Amount of P Sorbed Against Equilibrium P	70
2.15	P Adsorption Isotherm Plotting Between C/X Against C	72
2.16	Soil pH Effect on P Adsorption and Precipitation	75
2.17	P in Pasture System	87
2.18	Morphology of Red Clover	88
2.19	Morphology of Ryegrass	90
3.1	Electrical Conductivity (ds/m) of Salt Solutions Plotted Against Concentration of NaCl (g/L)	99
3.2	Pot was Inserted with Syringe Attached with the Tube	108
3.3	P Adsorption Isotherm for DP2 Soil Indicated the Maximum Adsorption at 0.31 mgP / g Dry Soil	111
4.1	P Adsorption Isotherm for DP1 (Control, No Salt)	116
4.2	P adsorption isotherm for JBU1 (Control, No Salt)	116
4.3	P Adsorption Isotherm for TG1 (No salt)	117
4.4	P Adsorption Isotherms Plotting between P Sorbed (mg/ g dry soil) and log c for 3 Soils without Salt Additions (Control)	117
4.5	P Adsorption Isotherms for DP1 Soil after Incubation with NaCl Salt	118
4.6	P Adsorption Isotherms for TG1 Soil after Incubation with NaCl Salt	119
4.7	P Adsorption Isotherms for JBU1 Soil after Incubation with NaCl Salt	119
4.8	Adsorption Isotherms of TG1 with NaCl Addition to Reaction Solution	120
4.9	Adsorption Isotherms of DP1 with NaCl Addition to Reaction Solution	121
4.10	Adsorption Isotherms of JBU1 with NaCl Addition to Reaction Solution	121
4.11	Red Clover Yield and P Level after 12 Weeks	134
4.12	Birdsfoot trefoil Yield and P Level after 12 Weeks	135
4.13	Orchard Grass Yield and P Level after 12 Weeks	135
4.14	Perennial Ryegrass Yield and P Level after 12 Weeks	136
4.15	Red clover Morphology at 6 Levels of P after 12 Weeks	136
4.16	Possible Response Curve of Pasture Plants to Varying P Additions	138

4.17	Red Clover Yield with Low Range of P Levels after 12 Weeks	139
4.18	Birdsfoot trefoil Yield with Low Range of P Levels after 12 Weeks	139
4.19	Orchard Grass Yield with Low Range of P Levels after 12 Weeks	140
4.20	Ryegrass Yield with Low Range of P Levels after 12 Weeks	140
4.21	Yield Comparison at 7 Levels of P for Red Clover after 12 Weeks	142
4.22	Yield Comparison at 7 Levels of P for Birdsfoot trefoil after 12 Weeks	143
4.23	Yield Comparison at 7 Levels of P for Orchard Grass after 12 weeks	143
4.24	Yield Comparison at 7 Levels of P for Ryegrass after 12 Weeks	144
4.25	Ryegrass Yield at 5 Levels of Salinity at 2 Different Harvest Periods	156
4.26	Morphology of Ryegrass at 5 Levels of Salinity at Optimum P	161
4.27	Yield of Red clover at 2 Levels of Salinity and 5 Levels of P	164
4.28	Yield of Birdsfoot trefoil at 2 Levels of Salinity and 5 Levels of P	166
4.29	Yield of Orchard Grass at 2 Levels of Salinity and 5 Levels of P	168
4.30	Yield of Ryegrass at 2 Levels of Salinity and 5 Levels of P	170
4.31	Red Clover Yield in Natural Saline Soil with Various P Levels Related to Maximum P Adsorption Capacity	177
4.32	Ryegrass Yield in Natural Saline Soil with Various P Levels Related to Maximum P Adsorption Capacity	178
A1	Multiplication Factors for Converting $EC_{1:5}$ to EC_{se}	225
A2	Common EC Measurement Conversions	227
A3	Map of DP1 and DP2	237
A4	Locations of Soil Samples for TG1 and JBU1	242

LIST OF SPECIAL NAMES OR ABBREVIATIONS

P = Phosphorus

EC = Electrical Conductivity

EC_{se} = EC_e = Electrical Conductivity of soil extract

dS/m = decisiemens/meter

ads = adsorption

ESP = Exchangeable Sodium Percentage

SAR = Sodium Adsorption Ratio

CEC = Cation Exchange Capacity

Mha = million hectares

ha = hectare

mL = millilitre

L = Litre

g = gram

mM = millimol

mm = millimetre

ppm = part per million

μm = micrometre

nm = nanometre

rpm = revolutions per minute

μS/cm = microsiemens/centimetre