



UNIVERSITI PUTRA MALAYSIA

**IMPROVEMENT OF PINEAPPLE PRODUCTION ON
TROPICAL PEAT THROUGH FERTILIZER USE**

A.H.M. RAZZAQUE

FP 1999 17

**IMPROVEMENT OF PINEAPPLE PRODUCTION ON
TROPICAL PEAT THROUGH FERTILIZER USE**

By

A.H.M. RAZZAQUE

**Thesis Submitted in Fulfilment of the Requirements for the
Degree of Doctor of Philosophy in the Faculty of Agriculture
Universiti Putra Malaysia**

July 1999



**FOR MY PARENTS
&
TO THE MEMORY OF MY
GRAND PARENTS**



ACKNOWLEDGEMENTS

Praises to Almighty Allah, the Cherisher and Sustainer of this wonderful world, whose blessings enabled the author to complete this project.

The author wishes to express his sincere gratitude to Dr. Mohamed Hanafi Musa, the Chairman of the Supervisory Committee for his active guidance, valuable advice and generous help during the research works and in the preparation of this dissertation.

The author is also grateful to Dr. Anuar Abdul Rahim and Dr. Ahmad Husni Mohd. Hanif (members of the supervisory committee) for their invaluable assistance and guidance at various stages of research works and in the preparation of this dissertation.

The author is grateful and thankful to the entire management of Peninsula (Pineapple) Plantations Sdn. Bhd., Simpang Rengam, Johor, especially to Mr. Lee Sing Kim, Mr. Koh Soo Koon and Mr. Faizul Abdul Ghani for their appreciation and kind co-operation during my stay and field research in the estate. The financial supports of the National Council for Scientific Research and Development Malaysia through the Intensification of Research in Priority Areas (IRPA) funding and the encouragement of UPM in research and development are gratefully acknowledged.

I am greatly indebted to the entire technical staff of the Department of Land Management, UPM, especially to Puan Fauziah Solaiman, Mr. Abdul Rahim Uttar



and Mr. Jamil Omar for their cooperation during my research works and for their friendly attitudes throughout my stay.

The author is indebted to the administrative authority of Bangladesh Institute of Nuclear Agriculture (BINA) for providing deputation and all sorts of help to accomplish his degree. The author is also thankful to all of his friends and colleagues whose names are impossible to list for their help and moral encouragement. Special thanks are due to Dr. M. Anisur Rahman and Bhabi, Dr. M. Syedul Islam and Bhabi, Dr. M.A. Saleque and Pinky Bhabi for providing the author with immense help and homely atmosphere to complete his difficult task.

Sincere appreciation goes to his parents, younger brother and sister, father in law, uncles and aunts for their love, sacrifices and spiritual support that made the author what he is. Last but not the least, the author is extremely grateful to his loving wife, Foara Hasan, lovely daughter and son, Sammanah Hasan and Salman Hasan for their patience, sacrifices and love which have been constant inspirations.



TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS.....	iii
LIST OF TABLES.....	xi
LIST OF FIGURES.....	xvii
ABSTRACT.....	xxiii
ABSTRAK.....	xxvi

CHAPTER

I INTRODUCTION.....	1
Statements of Problems.....	4
Objectives of the Study.....	5
II LITERATURE REVIEW.....	6
Peat soil.....	6
Physical Soil Conditions.....	6
Chemical Soil Conditions.....	8
Effect of Nutrients on Growth and Yield of pineapple.....	9
Nitrogen.....	9
Phosphorus.....	12
Potassium.....	15
Calcium.....	17
Magnesium.....	18
Copper.....	19
Combined Effect of N, P and K on Growth and Yield of Pineapple.....	21
Effect of Nutrients on the Quality of Pineapple.....	23
Nutrient Concentration and Fertilizer Requirements.....	26
Derivation of Critical Nutrient Concentrations.....	32
Relative Yield.....	32
Dry Matter Accumulation and Partitioning.....	33
Effect of Nutrients on Pineapple Root Growth.....	37
Nutrient Uptake and Recovery.....	39
Nitrogen.....	40
Phosphorus.....	42
Potassium.....	44
Calcium.....	46
Magnesium.....	47
Copper.....	48



Nutrient Antagonism.....	49
Leaching of Nutrients from Soil Profile.....	52
Conservation Tillage and Nutrient Requirements.....	57
Conclusions.....	59
III NUTRIENT REQUIREMENTS FOR PINEAPPLE PRODUCTION ON TROPICAL PEAT.....	62
Introduction.....	62
Materials and Methods.....	63
Site Description.....	63
Treatments and Experimental Design.....	64
Fertilizer Applications.....	65
Planting.....	66
Flower Induction and other Cultural Practices.....	66
Data Collection and Harvesting.....	66
Measurement of Sugar and Acidity of Fruits.....	68
Collection and Preparation of Soil Samples.....	68
Collection and Preparation Plant Samples.....	68
Soil Analysis.....	69
Physical Properties.....	69
Chemical Properties.....	69
Plant Analysis.....	70
Calculation of Maximum and Economic Optimum Levels of Fertilizer.....	71
Fertilizer Recovery.....	71
Nutrient Gain or Loss Analysis.....	72
Statistical Analysis.....	72
Results and Discussion.....	73
Effect of Nitrogen on Growth Characteristics of cv. Gandul..	73
Plant Height.....	73
Leaf Number.....	75
D-leaf Length, Area and Dry Weight.....	78
Influence of Nitrogen on D-leaf N Concentration.....	82
Effect of Nitrogen on Yield and Yield Attributes.....	86
Fruit length, Diameter and Fruit Core Diameter.....	86
Fruit Weight.....	89
Fruit Yield.....	91
Effect of Nitrogen on Quality.....	93
Sugar Content and Fruit Acidity.....	93
Relation between D-leaf N Concentration and Yield of Pineapple.....	96
Influence of Applied Nitrogen on N Uptake and Recovery...	98

Soil Nitrogen Content as Influenced by the Applied Nitrogen	101
Effect of Phosphorus on Growth Characteristics.....	103
Plant Height.....	103
Leaf Number.....	105
D-leaf Length, Area and Dry Weight.....	107
Influence of Phosphorus on D-leaf P Concentration.....	110
Effect of Phosphorus on Yield and Yield Attributes.....	113
Fruit length, Diameter and Fruit Core Diameter.....	113
Fruit Weight.....	115
Fruit Yield.....	117
Effect of Phosphorus on Fruit Quality.....	119
Sugar Content and Fruit Acidity.....	119
Relation between D-leaf P Concentration and Yield.....	121
Influence of Applied Phosphorus on P Uptake and Recovery.	123
Soil Phosphorus Content as Influenced by the Applied Phosphorus.....	126
Effect of Potassium on Growth Characteristics.....	129
Plant Height.....	129
Leaf Number.....	130
D-leaf Length, Area and Dry Weight.....	132
Influence of Potassium on D-leaf K Concentration.....	134
Effect of Potassium on Yield and Yield Attributes.....	138
Fruit length, Diameter and Fruit Core Diameter.....	138
Fruit Weight.....	140
Fruit Yield.....	142
Effect of Potassium on Fruit Quality.....	143
Sugar Content and Fruit Acidity.....	143
Relation between D-leaf K Concentration and Yield.....	145
Influence of Applied Potassium on K Uptake and Recovery..	147
Soil Potassium as Influenced by the Applied Potassium.....	149
Effect of Calcium on Growth Characteristics.....	152
Plant Height.....	152
Leaf Number.....	154
D-leaf Length, Area and Dry Weight.....	156
Influence of Calcium on D-leaf Ca Concentration.....	158
Effect of Calcium on Yield and Yield Attributes.....	162
Fruit Length, Diameter and Fruit Core Diameter.....	162
Fruit Weight.....	164
Fruit Yield.....	165
Effect of Calcium on Fruit Quality.....	166
Sugar Content and Fruit Acidity.....	166
Relation between D-leaf Ca Concentration and Yield.....	168
Influence of Applied Calcium on Ca Uptake and Recovery...	169
Soil Calcium Content as Influenced by the Applied Calcium.	172



Effect of Magnesium on Growth Characteristics.....	174
Plant Height.....	174
Leaf Number.....	175
D-leaf Length, Area and Dry Weight.....	177
Influence of Magnesium on D-leaf Mg Concentration.....	180
Effect of Magnesium on Yield and Yield Attributes.....	184
Fruit Length, Diameter and Fruit Core Diameter.....	184
Fruit Weight.....	186
Fruit Yield.....	187
Effect of Magnesium on Fruit Quality.....	188
Sugar Content and Fruit Acidity.....	188
Relation between D-leaf Mg Concentration and Yield.....	189
Influence of Applied Magnesium on Mg Uptake and Recovery.....	191
Soil Magnesium Content as Influenced by the Applied Magnesium.....	193
Effect of Copper on Growth Characteristics.....	195
Plant Height.....	195
Leaf Number.....	197
D-leaf Length, Area and Dry Weight.....	199
Influence of Copper on D-leaf Cu Concentration.....	201
Effect of Copper on Yield and Yield Attributes.....	204
Fruit Length, Diameter and Fruit Core Diameter.....	204
Fruit Weight.....	205
Fruit Yield.....	207
Effect of Copper on Fruit Quality.....	209
Sugar Content and Fruit Acidity.....	209
Relation between D-leaf Cu Concentration and Yield.....	210
Influence of Applied Copper on Cu Uptake and Recovery....	212
Soil Copper Contents as Influenced by the Applied Copper...	214
Conclusions.....	215
IV NUTRIENT SUPPLY, GROWTH AND DRY MATTER PARTITIONING IN PINEAPPLE.....	217
Introduction.....	217
Materials and Methods.....	219
Soil Sample Preparation and Potting.....	219
Treatment of the Experiment.....	220
Fertilizer Applications and other Cultural Practices.....	220
Data Collection and Harvesting.....	221
Root Collection and Preparation.....	221
Chemical Analysis.....	222
Derivation of Critical Nutrient Concentrations.....	222
Statistical Analysis.....	222



Results and Discussion.....	223
Influence of Nitrogen on Dry Matter Production and Partitioning.....	223
Influence of Applied Nitrogen on Leaf Nutrient Concentrations.....	227
Influence of Applied Nitrogen on Root Nutrient Concentrations.....	230
Relative Dry Matter Yield and Leaf N Concentration.....	232
Influence of Phosphorus on Dry Matter Production and Partitioning.....	235
Influence of Applied Phosphorus on Leaf Nutrient Concentrations.....	238
Influence of Applied Phosphorus on Root Nutrient Concentrations.....	241
Relative Dry Matter Yield and Leaf P Concentration.....	242
Influence of Potassium on Dry Matter Production and Partitioning.....	245
Influence of Applied Potassium on Leaf Nutrient Concentrations.....	248
Influence of Applied Potassium on Root Nutrient Concentrations.....	250
Relative Dry Matter Yield and Leaf K Concentration.....	252
Influence of Calcium on Dry Matter Production and Partitioning.....	254
Influence of Applied Calcium on Leaf Nutrient Concentrations.....	256
Influence of Applied Calcium on Root Nutrient Concentrations.....	259
Relative Dry Matter Yield and Leaf Ca Concentration.....	260
Influence of Magnesium on Dry Matter Production and Partitioning.....	263
Influence of Applied Magnesium on Leaf Nutrient Concentrations.....	265
Influence of Applied Magnesium on Root Nutrient Concentrations.....	267
Relative Dry Matter Yield and Leaf Mg Concentration.....	269
Influence of Copper on Dry Matter Production and Partitioning.....	271
Influence of Applied Copper on Leaf Nutrient Concentrations.....	274
Influence of Applied Copper on Root Nutrient Concentrations.....	276
Relative Dry Matter Yield and Leaf Cu Concentrations.....	277



	Conclusions.....	279
V	LEACHING OF NUTRIENTS IN PEAT SOIL.....	280
	Introduction.....	280
	Materials and Methods.....	281
	Soil Sample Preparation.....	281
	Leaching System.....	282
	Treatment of the Experiment.....	282
	Leachate and Soil Analysis.....	283
	Statistical Analysis.....	283
	Results and Discussion.....	284
	Leaching of Nitrogen in Peat Soil.....	284
	Distribution of Nitrogen in Soil Column.....	287
	Leaching of Phosphorus in Peat Soil.....	290
	Distribution of Phosphorus in Soil Column.....	293
	Leaching of Potassium in Peat Soil.....	298
	Distribution of Potassium in Soil Column.....	300
	Leaching of Calcium in Peat Soil.....	303
	Distribution of Calcium in Soil Column.....	305
	Leaching of Magnesium in Peat Soil.....	307
	Distribution of Magnesium in Soil Column.....	310
	Leaching of Copper in Peat Soil.....	314
	Distribution of Copper in Soil Column.....	316
	Conclusions.....	320
VI	FERTILIZER MANAGEMENT PRACTICES FOR PINEAPPLE PRODUCTION ON TROPICAL PEAT.....	321
	Nitrogen.....	322
	Phosphorus.....	324
	Potassium.....	326
	Calcium.....	328
	Magnesium.....	330
	Copper.....	332
VII	SUMMARY.....	334
	Future Works.....	342
	REFERENCES.....	343
	VITA.....	362



LIST OF TABLES

Table		Page
3.1	Physical and Chemical Properties of Peat Soils at the Two Experimental Sites.....	64
3.2	Effect of Nitrogen on Plant Height of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	73
3.3	Effect of Nitrogen on the Number of Leaves of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	76
3.4	Influence of Nitrogen and Plant Age on D-leaf Characteristics of Pineapple cv. Gandul Grown at Two Sites.....	79
3.5	D-leaf N Concentration as Influenced by the Applied Nitrogen in Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	82
3.6	Effect of Nitrogen on Yield Contributing Characters of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	86
3.7	Effect of Nitrogen on Fruit Yield of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	92
3.8	Effect of Nitrogen on Sugar and Acid Content in Fruits of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	94
3.9	Influence of Applied Nitrogen on N Uptake and Recovery by Pineapple cv. Gandul from Peat Soil at Two Sites.....	99
3.10	Total Nitrogen as Influenced by the Applied Nitrogen during Forcing and Harvesting of Pineapple at Two Sites of Peat Soil.....	101
3.11	Effect of Phosphorus on Plant Height of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	103
3.12	Effect of Phosphorus on the Number of Leaves of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	105



3.13	Influence of Phosphorus and Plant Age on D-leaf Characteristics of Pineapple cv. Gandul Grown at Two Sites.....	108
3.14	D-leaf P Concentration as Influenced by the Applied Phosphorus in Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	110
3.15	Effect of Phosphorus on Yield Contributing Characters of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	114
3.16	Effect of Phosphorus on Fruit Yield of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	118
3.17	Effect of Phosphorus on Sugar and Acid Content in Fruits of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	120
3.18	Influence of Applied Phosphorus on P Uptake and Recovery by Pineapple cv. Gandul from Peat Soil at Two Sites.....	123
3.19	Extractable Phosphorus as Influenced by the Applied Phosphorus during Forcing and Harvesting of Pineapple at Two Sites of Peat Soil.....	127
3.20	Effect of Potassium on Plant Height of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	129
3.21	Effect of Potassium on the Number of Leaves of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	131
3.22	Influence of Potassium and Plant Age on D-leaf Characteristics of Pineapple cv. Gandul Grown at Two Sites.....	133
3.23	D-leaf K Concentration as Influenced by the Applied Potassium in Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	135
3.24	Effect of Potassium on Yield Contributing Characters of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	139
3.25	Effect of Potassium on Fruit Yield of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	142
3.26	Effect of Potassium on Sugar and Acid Content in Fruits of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	144



3.27	Influence of Applied Potassium on K Uptake and Recovery by Pineapple cv. Gandul from Peat Soils at Two Sites.....	147
3.28	Exchangeable Potassium as Influenced by the Applied Potassium during Forcing and Harvesting of Pineapple at Two Sites of Peat Soil.....	150
3.29	Effect of Calcium on Plant Height of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	152
3.30	Effect of Calcium on the Number of Leaves of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	154
3.31	Influence of Calcium and Plant Age on D-leaf Characteristics of Pineapple cv. Gandul Grown at Two Sites.....	157
3.32	D-leaf Ca Concentration as Influenced by the Applied Calcium in Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	158
3.33	Effect of Calcium on Yield Contributing Characters of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	163
3.34	Effect of Calcium on Fruit Yield of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	166
3.35	Effect of Calcium on Sugar and Acid Content in Fruits of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	167
3.36	Influence of Applied Calcium on Ca Uptake and Recovery by Pineapple cv. Gandul from Peat Soil at Two Sites.....	170
3.37	Exchangeable Calcium as Influenced by the Applied Calcium during Forcing and Harvesting of Pineapple at Two Sites of Peat Soil.....	173
3.38	Effect of Magnesium on Plant Height of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	174
3.39	Effect of Magnesium on the Number of Leaves of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	176
3.40	Influence of Magnesium and Plant Age on D-leaf Characteristics of Pineapple cv. Gandul Grown at Two Sites.....	178



3.41	D-leaf Mg Concentration as Influenced by the Applied Magnesium in Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	181
3.42	Effect of Magnesium on Yield Contributing Characters of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	185
3.43	Effect of Magnesium on Fruit Yield of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	187
3.44	Effect of Magnesium on Sugar and Acid Content in Fruits of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	188
3.45	Influence of Applied Magnesium on Mg Uptake and Recovery by Pineapple cv. Gandul from Peat Soils at Two Sites.....	191
3.46	Exchangeable Magnesium as Influenced by the Applied Mg during Forcing and Harvesting of Pineapple at Two Sites of Peat Soil.....	193
3.47	Effect of Copper on Plant Height of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	195
3.48	Effect of Copper on the Number of Leaves of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	197
3.49	Influence of Copper and Plant Age on D-leaf Characteristics of Pineapple cv. Gandul Grown at Two Sites.....	199
3.50	D-leaf Cu Concentration as Influenced by the Applied Copper in Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	201
3.51	Effect of Copper on Yield Contributing Characters of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	204
3.52	Effect of Copper on Fruit Yield of Pineapple cv. Gandul Grown on Peat Soil at Two Sites.....	207
3.53	Effect of Copper on Sugar and Acid Content in Fruits of Pineapple cv. Gandul Grown at Two Sites of Peat Soil.....	209
3.54	Influence of Applied Copper on Cu Uptake and Recovery by Pineapple cv. Gandul from Peat Soil at Two Sites.....	212



3.55	Extractable Cu as Influenced by the Applied Copper during Forcing and Harvesting of Pineapple at Two Sites of Peat Soil.....	215
4.1	Influence of Nitrogen on Dry Matter Partitioning in Pineapple Grown at Site 1 and Site 2.....	226
4.2	Effect of Nitrogen on D-leaf Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	228
4.3	Effect of Nitrogen on Root Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	231
4.4	Influence of Phosphorus on Dry Matter Partitioning in Pineapple Grown at Site 1 and Site 2.....	237
4.5	Effect of Phosphorus on D-leaf Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	239
4.6	Effect of Phosphorus on Root Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	242
4.7	Influence of Potassium on Dry Matter Partitioning in Pineapple Grown at Site 1 and Site 2.....	247
4.8	Effect of Potassium on D-leaf Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	249
4.9	Effect of Potassium on Root Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	251
4.10	Influence of Calcium on Dry Matter Partitioning in Pineapple Grown at Site 1 and Site 2.....	256
4.11	Effect of Calcium on D-leaf Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	257
4.12	Effect of Calcium on Root Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	260
4.13	Influence of Magnesium on Dry Matter Partitioning in Pineapple Grown at Site 1 and Site 2.....	265
4.14	Effect of Magnesium on D-leaf Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	266



4.15	Effect of Magnesium on Root Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	268
4.16	Influence of Copper on Dry Matter Partitioning in Pineapple Grown at Site 1 and Site 2.....	273
4.17	Effect of Copper on D-leaf Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	275
4.18	Effect of Copper on Root Nutrient Concentrations in Pineapple Grown at Site 1 and Site 2.....	277
5.1	Loss of Nitrogen through Leaching at Site 1 and Site 2.....	287
5.2	Distribution of Total Nitrogen in Different Soil Depths after Leaching at Site 1 and Site 2.....	288
5.3	Loss of Phosphorus through Leaching at Site 1 and Site 2....	294
5.4	Distribution of Extractable Phosphorus in Different Soil Depths after Leaching at Site 1 and Site 2.....	294
5.5	Loss of Potassium through Leaching at Site 1 and Site 2.....	301
5.6	Distribution of Exchangeable Potassium in Different Soil Depths after Leaching at Site 1 and Site 2.....	302
5.7	Loss of Calcium through Leaching at Site 1 and Site 2.....	306
5.8	Distribution of Exchangeable Calcium in Different Soil Depths after Leaching at Site 1 and Site 2.....	306
5.9	Loss of Magnesium through Leaching at Site 1 and Site 2....	310
5.10	Distribution of Exchangeable Magnesium in Different Soil Depths after Leaching at Site 1 and Site 2.....	311
5.11	Loss of Copper through Leaching at Site 1 and Site 2.....	316
5.12	Distribution of Extractable Copper in Different Soil Depths after Leaching at site 1 and Site 2.....	317



LIST OF FIGURES

Figure		Page
3.1	Plant Height as Influenced by Different Plant Age at Site 1 and Site 2.....	74
3.2	Leaf Number as Influenced by Different Plant Age at Site 1 and Site 2.....	77
3.3	Effect on Nitrogen on the Number of Leaves at Different Plant Age at Site 2.....	77
3.4	Effect of Nitrogen on D-leaf N Concentration at Different Time after Planting at Two Sites.....	84
3.5	Effect of Nitrogen on Mean Fruit Weight of Pineapple at Site 1 and Site 2.....	90
3.6	Relation between D-leaf N Concentration and Fruit Yield of Pineapple at Site 1.....	97
3.7	Relation between D-leaf N Concentration and Fruit Yield of Pineapple at Site 2.....	97
3.8	Plant height as Influenced by Different Plant Age at Site 1 and Site 2.....	104
3.9	Leaf Number as Influenced by Different Plant Age at Site 1 and Site 2.....	106
3.10	Effect of Phosphorus on D-leaf P Concentration at Different Time after Planting at Two Sites.....	111
3.11	Effect of Phosphorus on Mean Fruit Weight of Pineapple at Site 1 and Site 2.....	116
3.12	Relation between D-leaf P Concentration and Fruit Yield of Pineapple at Site 1.....	122
3.13	Relation between D-leaf P Concentration and Fruit Yield of Pineapple at Site 2.....	122



3.14	Plant Height as Influenced by Different Plant Age at Site 1 and Site 2.....	130
3.15	Leaf Number as Influenced by Different Plant Age at Site 1 and Site 2.....	131
3.16	Effect of Potassium on D-leaf K Concentration at Different Time after Planting at Two Sites.....	136
3.17	Interaction of Potassium and Plant Age on D-leaf K Concentration at Site 2.....	137
3.18	Effect of Potassium on Mean Fruit Weight of Pineapple at Site 1 and Site 2.....	141
3.19	Relation between D-leaf K Concentration and Fruit Yield of Pineapple at Site 1.....	146
3.20	Relation between D-leaf K Concentration and Fruit Yield of Pineapple at Site 2.....	146
3.21	Plant height as Influenced by Different Plant Age at Site 1 and Site 2.....	153
3.22	Leaf Number as Influenced by Different Plant Age at Site 1 and Site 2.....	155
3.23	Effect of Calcium on D-leaf Ca Concentration at Different Time after Planting at Two Sites.....	159
3.24	Interaction of Calcium and Plant Age on D-leaf Ca Concentration at Site 1.....	160
3.25	Effect of Calcium on Mean Fruit Weight of Pineapple at Site 1 and Site 2.....	164
3.26	Relation between D-leaf Ca Concentration and Fruit Yield of Pineapple at Site 1.....	168
3.27	Relation between D-leaf Ca Concentration and Fruit Yield of Pineapple at Site 2.....	169
3.28	Plant height as Influenced by Different Plant Age at Site 1 and Site 2.....	175



3.29	Leaf Number as Influenced by Different Plant Age at Site 1 and Site 2.....	177
3.30	Interaction of Magnesium and Plant Age on D-leaf Dry Weight at Site 2.....	179
3.31	Effect of Magnesium on D-leaf Mg Concentration at Different Time after Planting at Two Sites.....	182
3.32	Interaction of Magnesium and Plant Age on D-leaf Mg Concentration at Site 1.....	183
3.33	Effect of Magnesium on Mean Fruit Weight of Pineapple at Site 1 and Site 2.....	186
3.34	Relation between D-leaf Mg Concentration and Fruit Yield of Pineapple at Site 1.....	190
3.35	Relation between D-leaf Mg Concentration and Fruit Yield of Pineapple at Site 2.....	190
3.36	Plant height as Influenced by Different Plant Age at Site 1 and Site 2.....	196
3.37	Leaf Number as Influenced by Different Plant Age at Site 1 and Site 2.....	198
3.38	Effect of Copper on D-leaf Cu Concentration at Different Time after Planting at Two Sites.....	202
3.39	Effect of Copper on Mean Fruit Weight of Pineapple at Site 1 and Site 2.....	206
3.40	Relation between D-leaf Cu Concentration and Fruit Yield of Pineapple at Site 1.....	211
3.41	Relation between D-leaf Cu Concentration and Fruit Yield of Pineapple at Site 2.....	211
4.1	Influence of Nitrogen on (a) Leaf (b) Stem and (c) Root Dry Matter Weights at Site 1 and Site 1.....	224
4.2	Relation between Relative Dry Matter Yield and N Concentration in D-leaves of Pineapple at Site 1.....	233



4.3	Relation between Relative Dry Matter Yield and N Concentration in D-leaves of Pineapple at Site 2.....	233
4.4	Influence of Phosphorus on (a) Leaf (b) Stem and (c) Root Dry Matter Weights at Site 1 and Site 2.....	236
4.5	Relation between Relative Matter Dry Yield and P Concentration in D-leaves of Pineapple at Site 1.....	243
4.6	Relation between Relative Dry Matter Yield and P Concentration in D-leaves of Pineapple at Site 2.....	243
4.7	Influence of Potassium on (a) Leaf (b) Stem and (c) Root Dry Matter Weights at Site 1 and Site 2.....	246
4.8	Relation between Relative Dry Matter Yield and K Concentration in D-leaves of Pineapple at Site 1.....	253
4.9	Relation between Relative Dry Matter Yield and K Concentration in D-leaves of Pineapple at Site 2.....	253
4.10	Influence of Calcium on (a) Leaf (b) Stem and (c) Root Dry Matter Weights at Site 1 and Site 2.....	255
4.11	Relation between Relative Dry Matter Yield and Ca Concentration in D-leaves of Pineapple at Site 1.....	261
4.12	Relation between Relative Dry Matter Yield and Ca Concentration in D-leaves of Pineapple at Site 2.....	261
4.13	Influence of Magnesium on (a) Leaf (b) Stem and (c) Root Dry Matter Weights at Site 1 and Site 2.....	264
4.14	Relation between Relative Dry Matter Yield and Mg Concentration in D-leaves of Pineapple at Site 1.....	269
4.15	Relation between Relative Dry Matter Yield and Mg Concentration in D-leaves of Pineapple at Site 2.....	270
4.16	Influence of Copper on (a) Leaf (b) Stem and (c) Root Dry Matter Weights at Site 1 and Site 2.....	272
4.17	Relation between Relative Dry Matter Yield and Cu Concentration in D-leaves of Pineapple at Site 1.....	278



4.18	Relation between Relative Dry Matter Yield and Cu Concentration in D-leaves of Pineapple at Site 2.....	278
5.1	Nitrogen Concentration in the Leachate from Fertilized Soil Column at Site 1 and Site 2.....	285
5.2	Leaching of Nitrogen from Soil Column with Time at Site 1 and Site 2.....	285
5.3	Interaction between Nitrogen Treatment and Soil Column Depth at Site 1.....	289
5.4	Phosphorus Concentration in the Leachate from Fertilized Soil Column at Site 1 and Site 2.....	291
5.5	Leaching of Phosphorus from Soil Column with Time at Site 1 and Site 2.....	292
5.6	Interaction between Phosphorus Treatments and Soil Column Depths at Site 1.....	295
5.7	Interaction between Phosphorus Treatments and Soil Column Depths at Site 2.....	295
5.8	Potassium Concentration in the Leachate from Fertilized Soil Column at Site 1 and Site 2.....	298
5.9	Leaching of Potassium from Soil Column with Time at Site 1 and Site 2.....	299
5.10	Calcium Concentration in the Leachate from Fertilized Soil Column at Site 1 and Site 2.....	304
5.11	Leaching of Calcium from Soil Column with Time at Site 1 and Site 2.....	304
5.12	Magnesium Concentration in the Leachate from Fertilized Soil Column at Site 1 and Site 2.....	308
5.13	Leaching of Magnesium from Soil Column with Time at Site 1 and Site 2.....	308
5.14	Interaction between Magnesium Treatments and Soil Column depth at Site 2.....	312



5.15	Copper Concentration in the Leachate from Fertilized Soil Column at Site 1 and Site 2.....	315
5.16	Leaching of Copper from Soil Column with Time at Site 1 and Site 2.....	315
5.17	Interaction between Copper Treatment and Soil Column Depth at Site 1.....	318
5.18	Interaction between Copper Treatment and Soil Column Depth at Site 2.....	319
6.1	Effect of Fertilizer N on Fruit Yield at Site 1.....	323
6.2	Effect of Fertilizer N on Fruit Yield at Site 2.....	323
6.3	Effect of Fertilizer P on Fruit Yield at Site 1.....	325
6.4	Effect of Fertilizer P on Fruit Yield at Site 2.....	325
6.5	Effect of Fertilizer K on Fruit Yield at Site 1.....	327
6.6	Effect of Fertilizer K on Fruit Yield at Site 2.....	327
6.7	Effect of Fertilizer Ca on Fruit Yield at Site 1.....	329
6.8	Effect of Fertilizer Ca on Fruit Yield at Site 2.....	329
6.9	Effect of Fertilizer Mg on Fruit Yield at Site 1.....	331
6.10	Effect of Fertilizer Mg on Fruit Yield at Site 2.....	331
6.11	Effect of Fertilizer Cu on Fruit Yield at Site 1.....	333
6.12	Effect of Fertilizer Cu on Fruit Yield at Site 2.....	333



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy.

**IMPROVEMENT OF PINEAPPLE PRODUCTION ON
TROPICAL PEAT THROUGH FERTILIZER USE**

By

A.H.M. RAZZAQUE

July 1999

Chairman: Mohamed Hanafi Musa, Ph.D.

Faculty: Agriculture

Information on the agronomic characteristics and nutritional requirements of pineapple (cv. Gandul) is lacking in peat soil. Therefore, studies in the field at two sites (site 1 and site 2), glasshouse and laboratory were carried out to investigate the effects of N, P, K, Ca, Mg and Cu on growth, yield and quality of pineapple and to assess the loss of the applied nutrients through leaching. Six levels of each of N, P, K, Ca, Mg and Cu were studied separately at each site of the field in a RCB design with three replications. In the glasshouse, three levels of each of the above nutrients were studied with soils from both sites. Leaching studies using soil columns were conducted in the laboratory with two levels of each nutrient for a period of 30 days. Plant height and leaf number increased with age up to forcing time at both sites. D-leaf length and area were influenced with N application, while the leaf dry weight was influenced with Mg at site 2. The leaf nutrient concentrations were influenced by N, P, Ca and Mg at site 1 and by N, P and K applications at site 2. Leaf nutrient concentrations increased up to six months of plant age and declined at forcing at both



sites. The mean fruit weight of pineapple responded quadratically with N application at both sites and with Ca at site 1 and declined linearly with the increment of P at site 2. There was no significant effect of nutrients on fruit quality except for P on sugar content at site 1. Fruit yield was positively correlated with leaf N concentrations at both sites and negatively correlated with Cu at site 1. The highest nutrient recoveries (%) were 15 and 16 (N); 53 and 45 (P_2O_5); 13 and 28 (K_2O); 41 and 29 (CaO); 55 and 50 (MgO); and 0.81 and 3 (CuO) at site 1 and site 2, respectively. Leaf dry weight responded with the increment of N, K and Cu at site 1 and with N, P, Ca and Mg at site 2. Stem dry weight was influenced with the increment of N, P, Mg and Cu at site 1 and with N, P and Cu at site 2. Root dry weight decreased with the increment of P and Cu applications at site 1 and with Ca and Cu at site 2. There was an unbalanced accumulation of dry matter in the stem (<8%) at site 2. Nutrient concentrations in leaves and roots varied with the applied nutrients at both sites. The total loss of nutrients (70 - 80%) occurred within 3 - 4 days of leaching at site 1, while those percentages leached within 7 days at site 2. The total N content in soil increased with N application at site 2. The P content increased in the unfertilized soil at site 1. Exchangeable K and extractable Cu increased with K and Cu applications at both sites. Most of the applied P and Cu remained at the surface layer but N and Mg moved down the soil profile at site 1. At site 2, N, Mg and Cu contents remained at the surface layer but K content increased at the bottom layer of the column. The calculated optimum fertilizer rates ($kg\ ha^{-1}$) were N = 872 and 750; P_2O_5 = 24 and 48; K_2O = 400 and 266; CaO = 108 and 84; MgO = 24 and 36 and CuO = 2 and 3 for site 1 and site 2, respectively.