

Soil Fertility Decline in the Tropics with Case Studies on Plantations

Alfred E. Hartemink

International Soil Reference and Information Centre (ISRIC)

Wageningen

The Netherlands

CABI Publishing

Contents

Preface	ix
Foreword	xi
Acknowledgements	xiii
1. Introduction	1
General	1
This Book and its Rationale	2
Aims and Approach	7
References	8
2. Human Population and Soil Degradation	10
Malthus and his Followers	10
Population Growth	13
Food Production and Soil Science	16
Trends in Crop Yields	24
Soil Resources and Limitations	26
Soil Fertility	30
Tropical Land Use and Management	34
Soil Degradation	43
Sustainable Land Management	48
Discussion and Conclusions	51
References	53
3. Plantation Agriculture	61
Introduction	61
History	62
Importance and Spreading of Plantation Agriculture	64

Research in Plantation Crops	66
Pros and Cons of Plantation Agriculture	69
Trends in Crop Yields	72
References	75
4. Soil Fertility Decline – Theoretical Considerations	79
Introduction	80
Spatial and Temporal Boundaries	80
Data Types	86
Long-term Experiments	92
Soil Sampling, Soil Analysis and Errors	97
Spatial and Temporal Variation	103
Soil Changes and Nutrient Removal	107
Effects of Bulk Density	117
Interpretation of the Results	123
Discussion and Conclusions	128
References	129
5. Annual Crops	139
Selection Criteria and Soil Chemical Properties	140
Measured Change in Soil Properties – Type I Data	142
Measured Change in Soil Properties – Type II Data	147
Rates of Change	151
Semiquantitative Studies	155
Discussion and Conclusions	158
References	161
6. Perennial Crop Plantations	165
Soil Changes	166
Soil Erosion Under Perennial Crops	172
Type I and II Data	176
Rates of Change in Soil Chemical Properties	181
Semiquantitative Studies	185
Soil-process-oriented Studies	187
Environmental Impact	190
Discussion and Conclusions	191
References	192
7. Forest Plantations	197
History, Extent and Present Status	197
Soil Erosion on Forest Plantations	199
Type I and II Data	199
Rates of Change in Soil Chemical Properties	206
Semiquantitative and Soil-process-oriented Studies	206
Environmental Impact	214
Discussion and Conclusions	216
Differences Between Perennial Crops and Forest Plantations	220
References	221

8. Sugarcane Plantations	227
Soil Erosion Under Sugarcane	227
Type I and II Data	229
Rates of Change in Soil Chemical Properties	240
Semiquantitative Studies	240
Soil-process-oriented Studies	247
Environmental Impact	250
Discussion and Conclusions	253
References	255
9. Case 1 – Sugarcane Plantation, Papua New Guinea	264
Introduction	264
Physical Environment	265
Research Methods	268
Type I and II Data	270
Rates of Change	275
Semiquantitative Data	278
Changes in Leaf Nutrient Contents	278
The Effects on Yield	283
Discussion and Conclusions	284
References	286
10. Case 2 – Sisal Plantations, Tanzania	289
Introduction	290
Physical Environment	293
Research Methods	297
Type I and II Data	300
Rates of Change	304
Semiquantitative Data	304
The Effects on Yield	308
Discussion and Conclusions	309
References	313
11. Synthesis	315
Rates of Change in Soil Chemical Properties	315
Changes in Different Land-use Systems	317
Changes by Soil Order	319
Discussion	320
Effect on Crop Production	326
Sustainable Land Management	333
References	335
12. Summary and Conclusions	339
Rates of Soil Fertility Decline	340
Differences Between Land-use Systems	340
Quantification of Soil Fertility Decline	341
The Effects of Soil Fertility Decline	342
Future Research	343
Author Index	345
Subject Index	351