Table of content

Acknowledgment	iii
Abstract (English)	vi
Abstract (Thai)	xi
List of tables	xxiii
List of illustrations	xxix
Definitions and abbreviations	xxxiii
Introduction	1
Chapter 1 Literature review	5
1.1 Upland cultivation systems in Northern Thailand	5
1.2 Extent, distribution and forms of shifting cultivation	7 6
1.3 Restoration of upland rice yields in degraded shifting	cultivation 10
1.3.1 Concepts and ideas of restoration	A //11
1.3.2 Dynamic restoration	12
1.3.3 Degradation of shifting cultivation	13
1.4 Some attempts to restore degraded shifting cultivation	with
fallow management.	14
1.5 Macaranga denticulata	1080 ₁₉ h
Chapter 2 The study village	i Unive22sit
A 2.1 Introduction g h t s r e	
2.2 Materials and methods	24
2.2.1 Village survey and key informant interview	24
2.2.2 Land use survey and mapping	25

xvii

2.3 Results	31
2.3.1 Infrastructure and climate	31 :
2.3.2 Soil	33
2:3.3 Water	33
2.3.4 Population and migration	34
2.3.5 Social organization, kinships and community	
networks.	35
2.3.6 Settlement patterns	39
2.3.7 Source of cash income and livelihood activities	44
2.3.8 External supports and services	47
2.3.9 Land ownerships and management for shifting	
cultivation	50
2.4 Discussions	55
Chapter 3 Farmers' management of shifting cultivation and crop	
diversity in reduced rotation cycle	57
3.1 Introduction	57
3.2 Materials and methods	59
3.3. Results	61
3.3.1 Management of shifting cultivation	61
1) Management of shifting cultivation in Tee	
Cha with communal on collective decision	61
2) Slashing and burning the fields	62
3) Planting upland rice and divers swidden crops	64
4) Weed, pest and diseases	65

xviii

5) Crops harvest	66
3.3.2 Management of short fallow	68
1) Cropping phase	68
2) Fallowing phase	69
3) Distribution of Macaranga denticulate	69
3.3.3 Maintenances of crops diversity	72
1) Genetic diversity of upland rice	72
2) Species diversity of swidden crops	79
3) Diversity of swidden crops between household	84
4) Diversity between timing in the cropping season	85
3.4 Discussion	86
Chapter 4 Fallow succession and regeneration of Macaranga in	
reduced rotation cycle	89
4.1 Introduction	89
4.2 Materials and methods	92
4.2.1 Plant counts and species diversity of fallows	92
4.2.2 Productivity of fallows	93
4.2.3 Seed production and seed bank	94
4.2.4 Recruitment, establishment and survival rates of	Joln
Macaranga seedlings	ives sit
4.2.5 Seed germination and variability tests	95
4.3 Results	98
4.3.1 Species composition	98
4.3.2 Fallow succession	98

4.3.3 Abundance, species richness and evenness	107
4.3.4 Productivity of forest fallow	110
1) Above ground biomass	110
2) Nutrient uptake	113
4.3.5 Regeneration of Macaranga	115
1) The plant	115
2) Seed rain	119
3) Seed bank	120
4) Seedling recruitment	122
4.1) Germination of seed bank	122
4.2) Seedling survival	123
4.4 Discussion	125
4.4.1 Fallow succession and species diversity	125
4.4.2 Fallow production	126
4.4.3 Regeneration of <i>Macaranga</i>	127
Chapter 5 Upland rice and Pada (Macaranga denticulata) in fallow	
Succession	129
5.1 Introduction	129
5.2 Materials and methods	131
C 5.3 Results by Chiang Mai Un	133
5.3.1 Fallow biomass and nutrient content	133
5.3.2 Soil fertility characteristics before slashing and	V. C
burning and under rice	137
5.3.3 Upland rice nutrition and yield	141

5.4 Discussion	147
5.4.1 Fallow biomass and nutrient content	147
5.4.2 Soil fertility characteristics before slashing and	
burning and under rice	148
5.4.3 The effect of dominant Macaranga on upland	
rice yield	148
Chapter 6 Macaranga denticulata and AM-fungi Association	149
6.1 Introduction	150
6.2 Materials and methods	151
6.3 Results	153
6.3.1 Height of Macaranga seedling	153
6.3.2 Shoot and root dry weight	156
6.3.3 Nutrient accumulates of shoot and root part	159
6.4 Discussion	168
Chapter 7 Restoration of degraded fallows with supplement ash	
and fertilities	169
7.1 Introduction	169
7.2 Materials and methods	171
7.2.1 Nopporn's plot	171
7.2.2 Tucare's plot Chiang Mai Un	V 1725 11
7.2.3 Crop management	172
7.2.4 Plot size and data collection	173

7.3 Results	178
7.3.1 The fallow biomass and nutrient content	178
7.3.2. Effects of burned biomass and phosphorus in	
Noppon's plot	179
1) Plant height and tiller numbers	179
2) Yield and yield component	182
3) The nutrient content of upland rice	183
3.1) At 35 days after rice seeding	183
3.2) At upland rice maturity	184
7.3.3 Effects of burned biomass and fertility application in	
Tucare's plot	186
1) Plant height and number of tillers	186
2) Yield and yield component	189
3) Yield component	190
4) The nutrient content of upland rice	192
4.1) The nutrient concentration of upland	
rice at 35 days	192
4.2) The nutrient content of upland rice	
at maturity	193
7.4 Discussion by Chiang Mai University	196
Chapter 8 General discussion	19 9
8.1 The situation of study village	199
8.2 Farmers' management of shifting cultivation and crop diversity	
in reduced cycle	201

8.3 Fallow succession and regeneration of <i>Macaranga</i> in reduced	
cycle	202
8.4 The effects of Macaranga denticulata on upland rice in short	
fallow in shifting cultivation	203
8.5 The association between Macaranga denticulata and AM-fungi	204
8.6 Restoration of degraded fallows with supplement ash and	
fertilizers	204
8.7 General concussion	206
8.8 Future research	206
References	207
Appendix	224
Curriculum vitae	282
TAI UNIVERSITY	

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved

xxiii

List of tables

Table		Page
1.1	Extent of land under shifting cultivation in mountainous mainland	
	Southeast Asia region.	7
2.1	Population and households in Tee Cha village	35
2.2	The household settled and moved of the Tee Cha villager in 1937 – 2004	40
2.3	Livelihood activities of villagers in Tee Cha village	46
2.4	The number of household have rice enough for consumer in all year	47
2.5	The development of Tee Cha farmers in 1958 – 2004	49
2.6	The type and area of land use of Pwo Karen in Tee Cha village in 2004	52
3.1	Activities of rotational shifting cultivation of farmers in Tee Cha village	67
3.2	The name of local upland rice varieties in Tee Cha village between	
	year 2000-2004	73
3.3	Varietal turnover in Tee Cha, 2000-2004	74
3.4	Number of farmers planted to local upland rice varieties during	
	year 2000-2004	75
3.5	The number of species type of the farmers planting in the cropping	
	year 2001-2004	80
3.6	Swidden crops species in the rotation shifting cultivation	82 S
3.7	Changes in species richness among sample households between	v e
	year 2001-2004	83

xxiv

3.8	The farmers name, planting area, sample plot, sample area, species	
	richness, and shannon-weaver index of the study between households	84
3.9	The diversity crops between times in the cropping season of	
	Thongdee plot year 2004	85
4.1	Number of plant species in various land use stages and field types	
	of Tee Cha village	91
4.2	The number species by plant types in different fallow fields	100
4.3	The number of species between different Macaranga denticulata	
	densities area in different fallow re-growth	106
4.4	Number of Macaranga denticulata (trees ha-1) in the dense and sparse	
	area of different years of fallow regrowth	108
4.5	Abundance of Macaranga denticulata and other species in fallow	
	re-growth with dense and sparse Macaranga	108
4.6	Plant numbers, species richness and shannon-weaver's index in	
	fallow regeneration of different fallow ages	109
4.7	The above ground biomass (ton ha ⁻¹) between different	
	Macaranga denticulata density area of Tee Cha village	111
4.8	Comparison the above ground biomass of plant species (ton ha ⁻¹) at	
	year 6 between dense and sparse areas	112
4.9	Numbers plant (tree ha ⁻¹) and above ground biomass (ton ha ⁻¹) at	
	year 6 between dense and sparse areas	112
4.10	Above ground nutrient contents in the fallow vegetation after seven	
	year of regeneration of a rotation shifting cultivation in year 2000	114
4.11	Seed production of <i>Macaranga</i> in the fallow years (seeds tree ⁻¹)	119

4.12	The seeds in the soil (seeds m ⁻² .) from different <i>Macaranga denticulata</i>	
	density area in the 6 th fallow years	120
4.13	Viability test of Macaranga seeds from trees	121
4.14	Viability test of Macaranga seeds recovered from soil at different	
	depth of seed survived	121
4.15	Percentage of Macaranga seeds germination test	122
4.16	Number of Macaranga seedlings (per ha ⁻¹) in the densely and sparsely	
	populated area of different months in the cropping year	123
4.17	Numbers of new plants in area after cropping rice 1 year (2003) and	
	2 Years (2002)	124
5.1	Above and below ground biomass (ton ha ⁻¹) in the fallow vegetation	
	after seven year of regeneration of cropping year 2000 – 2005	133
5.2	Above ground biomass (ton ha ⁻¹) in the fallow vegetation after seven	
	year of regeneration of a rotational shifting cultivation in year 2000	135
5.3	Above ground nutrient contents in the fallow vegetation after seven	
	year of regeneration of a rotation shifting cultivation in year 2000	136
5.4	pH and OM (%) of the soil samples collected from every fallow	
	regrowth in year 2002	138
5.5	Nutrient concentration of rotational shifting cultivation of the	
	soil samples collected from every fallow regrowth in year 2002	139
5.6	Fertility characteristics of the soil of the study area year 2000, in a	
	rotation shifting cultivation system in northern Thailand, before	
	burning and 30 days after rice sowing	140

5.7	Nutrient concentration in the upland rice (whole tops) of the study	
	area year 2000 at 30 days from sowing, in areas fallowing	
	Macaranga at low and high densities in a rotation shifting	
	cultivation system in northern Thailand	141
5.8	The yield of upland rice in seven years rotation of year 2000-2004,	
	in area fallowing Macaranga at low and high densities during	
	the fallow period, in a rotation shifting cultivation system in	
	northern Thailand	142
5.9	The yield of upland rice in seven and four years rotation of the study	
	area year 2000, in area fallowing Macaranga at low and high	
	densities during the fallow period, in a rotation shifting cultivation	
	system in northern Thailand	143
5.10	Range and variation of rice yield in seven years rotation of the study	
	area year 2000, in areas following Macaranga at low and high	
	densities during the fallow period, in a system of rotational	
	shifting cultivation in northern Thailand	144
5.11	Yield components of upland rice of the study area year 2000 in a	
	rotational shifting cultivation in northern Thailand with dense	
	and sparse Macaranga densities during the fallow period	144
5.12	Nutrient concentration and contents of the study area year 2000 at	
	maturity of the rice after fallow with dense and sparse Macaranga	
	in a rotational shifting cultivation in northern Thailand	146
6.1	Soil characteristic form Mae Hia research station and Tee Cha village	152

xxvii

6.2	Height (cm) of Macaranga seedling after emergence on effect of	
	mycorrhiza fungi, N and P	154
6.3	Effects of AM fungi inoculation and N (Urea) and P (triple super	
	phosphate) application on dry weight of Macaranga seedling	
	at 6 months	157
6.4	Shoot nutrient content of Macaranga seedling 6 months after germination	
	on effect of mycorrhiza fungi and fertilizer	160
6.5	Root nutrient content of Macaranga seedling 6 months after germination	
	on effect of mycorrhiza fungi and fertilizer	163
6.6	Total nutrient content of Macaranga seedling 6 months after germination	
	on effect of mycorrhiza fungi and fertilizer	166
7.1	Soil characteristic of experimental sites in shifting cultivation field,	
	Nopporn's and Tucare's plots	76
7.2	The biomass productivity (ton ha ⁻¹) of Nopporn's and Tucare's plots	
	before burning	178
7.3	Nutrient content (kg ha ⁻¹) in fallow biomass of Nopporn's and	
	Tucare's plots	179
7.4	Effects of burned biomass and phosphorus on height and tiller	
	numbers of upland rice at 125 days from sowing, Nopporn's plot	180
7.5	The yield of upland rice (ton ha ⁻¹) between different treatments,	
	Nopporn's plot	182
7.6	The yield component of upland rice between different treatments,	
	Nopporn's plot	183

xxviii

7.7	The analysis of nutrient concentration at 35 days after rice seeding	
	between different treatments, Nopporn's plot	183
7.8	Effects of treatment on nutrient content in grain, straw and total plant at	
	125 days from seeding, Nopporn's plot	185
7.9	The analysis of height of upland rice between different treatments,	
	Tucare's plot	187
7.10	Effects of burned biomass on tillers hill ⁻¹ from 35 to 125 days from	
	seeding, Tucare's plot	188
7.11	Effects of fertilizers on tillers hill ⁻¹ from 35 to 125 days from seeding,	
	Tucare's plot	188
7.12	Effects of fertilizers on tillers hill ⁻¹ from 35 to 125 days from	
	seeding, Tucare's plot	190
7.13	The effect of burned biomass and fertilizers on components of upland	
	rice yield, Tucare's plot	191
7.14	The analysis of nutrient concentration at 35 days after seeding	
	between treatments, Tucare's plot	192
7.15	The effect of burned biomass on nutrient content in the grain, straw and	
	total of upland rice at harvest period, Tucare's plot	194
7.16	The effect of fertilizer on nutrient content in the grain, straw and total of	
	upland rice at harvest period, Tucare's plot	195
	opyright [©] by Chiang Mai Univ	
	opyright by Chang Mai Office	

xxix

List of illustrations

Figur	re p	age
1.1	Provincial boundaries of Northern Thailand.	8
2.1	Northern Thailand and study village in Mae Hong Son province	27
2.2	Mae Hong Son and district boundary	28
2.3	Sop Moei district and sub-district boundary	29
2.4	Study site, Tee Cha, and other highland villages in Sop Moei	
	sub-district, Mae Hong Son province	30
2.5	Rainfall distribution in Tee Cha (2003-05) and Mae Sariang (1994-2003)	₂ 32
2.6	Monthly temperature in Tee Cha (2003-05) and Mae Sariang (1994-2003)	32
2.7	Village administrative organization (source: key informant	
	interview 2002)	38
2.8	Topography and boundary of rotational shifting cultivation areas	
	of Tee Cha village in 1937-1957	41
2.9	Topography and boundary of rotational shifting cultivation areas	
	of Tee Cha village in 2004	42
2.10	Pattern of household settled and village movement in 1937-1957	43
2.11	Tee Cha village's land use in 1997-2004	51
2.12	Land allocation of farmers in Tee Cha village between years 2000-2005	53
2.13	Pattern of land occupation for upland rice in shifting cultivation	54
3.1	"Bue Che Bao" it is ceremonial seven-hole rice in a small square	65
3.2	Distribution of Macaranga denticulata density in rotate field of	
	Tee Cha Village	71

3.3	Distribution of upland rice varieties used in cropping year 2000	76
3.4	Distribution of upland rice varieties used in cropping year 2001	76
3.5	Distribution of upland rice varieties used in cropping year 2002	77
3.6	Distribution of upland rice varieties used in cropping year 2003	77
3.7	Distribution of upland rice varieties used in cropping year 2004	78
3.8	Distribution of upland rice varieties used in cropping year 2005	78
3.9	The non-rice crops in shifting cultivation.	79
4.1	Map showing sampling sites and monitoring in a study of the	
	dynamic of Macaranga	97
4.2a	The composition of species in the dense area of Macaranga between	
	in each fallow year	101
4.2b	The composition of species in the sparse area of Macaranga between	
	in each fallow year	102
4.3	The succession stage of the rotational shifting cultivation in Tee Cha	
	Village	103
4.4	The diagram of plants in the difference fields' age of rotate system	
	(cropping year= plot 2004, 2 years fallow= plot 2002, 4 years	
	fallow= plot 2000 and 6 years fallow= plot 1998; plot size 10m X 10m)	104
4.5	Stages of fallow succession in reduced cycle of shifting cultivation with	
	dominant of Macaranga denticulata	105
4.6	The growth and development cycle of Macaranga denticulata	116
4.7	The inflorescences and flowers of Macaranga denticulata between	
	male and female	117
4.8	The Macaranga denticulata abundant in the field of Tee Cha village	118

6.1	Changes in seedling height of <i>Macaranga</i> , AM inoculation ($M_0 = nil$;	
	M_+ = inoculated), N (N ₀ = nil; N ₊ = 120 kg N ha ⁻¹) and P (P ₀ = nil;	
	$P_{+} = 120 \text{ kg P ha}^{-1}$	153
6.2	Effects of interaction between Mycorrhyza ($M_0 = nil$; $M_+ = inoculated$)	
	and P ($P_0 = \text{nil}$; $P_+ = 120 \text{ kg P ha}^{-1}$) on height (cm) of <i>Macaranga</i>	
	seedling	155
6.3	Interaction effect of Mycorrhiza ($M_0 = \text{nil}$; $M_+ = \text{inoculated}$) and fertilizer	
	$(N_0 = nil; N_+ = 120 \text{ kg N ha}^{-1}; P_0 = nil; \text{ and } P_+ = 120 \text{ kg P ha}^{-1}) \text{ on}$	
	shoot(a), root(b) and total(c) dry weight of Macaranga seedling	158
6.4	Interaction effect of Mycorrhiza ($M_0 = nil$; $M_+ = inoculated$) and fertilizer	
	$(N_0 = nil; N_+ = 120 \text{ kg N ha}^{-1}; P_0 = nil; \text{ and } P_+ = 120 \text{ kg P ha}^{-1}) \text{ on}$	
	nutrient content in shoot	162
6.5	Interaction effect of Mycorrhiza ($M_0 = nil$; $M_+ = inoculated$) and fertilizer	
	$(N_0 = nil; N_+ = 120 \text{ kg N ha}^{-1}; P_0 = nil; \text{ and } P_+ = 120 \text{ kg P ha}^{-1}) \text{ on}$	
	nutrient content in root	164
5.6	Interaction effect of Mycorrhiza ($M_0 = nil; M_+ = inoculated$) and fertilizer	
	$(N_0 = nil; N_+ = 120 \text{ kg N ha}^{-1}; P_0 = nil; \text{ and } P_+ = 120 \text{ kg P ha}^{-1}) \text{ on}$	
	nutrient content in total plant	167
7.1	Experimental sites in shifting cultivation field, cropping year 2003	175
7.2	Nopporn's plot was taken to represent relatively rich and high fertility	
	site with dominance of Macaranga trees	177
7.3	Tucare's plot was located on the other side of the field with slope not	
	exceeding 35 degree	177

7.4	The height (cm) growth of upland rice of between different	
	management of densely populated Macaranga area in year	
	2003, Nopporn's plot	181
7.5	The number of tillers per hill of upland rice with different fertility	
	management of densely populated Macaranga area in year 2003,	
	Nopporn's plot.	181
7.6	The height (cm) growth of upland rice of between different treatment	186
	THE TOTAL UNIVERSITY OF THE PARTY OF THE PAR	

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved

xxxiii

Definitions and abbreviations

Definitions

Dense Macaranga area the areas have Macaranga trees average 4,000 trees ha-1

Sparse Macaranga area the areas have Macaranga trees average 1,000 trees ha-1

Abbreviations

mg milligram

g gram

kg kilogram

ton 1000 kilogram

mm millimeter

cm centimeter

ha hectare

ppm gram part per million

°C degree Celsius

% percentage

N nitrogen

P phosphorus

K Opyrigh potassium V Chiang Mai Universit

Ca calcium f c r a c a r v a c

Mg magnesium