Appendix

Appendix A: Field data for chapter 2.

Table A-1 Average of climate of Tee Cha village compared with Mae Sarieng province.

	Temperature (%)						Rainfall (mm)	
	Mae Sarieng			Tee Cha			Mae	Tee
	Max	Min	Average	Max	Min	Average	Sarieng	Cha
January	32.0	13.6	22.8	33.5	10.1	21.8	0	0
February	34.2	13.5	23.8	35.5	9.5	22.5	12	0
March	36.3	17.3	26.8	38.1	14.3	26.2	31	0
April	37.7	21.8	29.7	41.2	14.9	28.0	60	2
May	34.4	22.2	28.3	37.0	16.0	26.9	197	109
June	31.9	23.5	27.7	31.2	18.6	24.9	168	335
July	30.7	23.2	26.9	30.3	19.1	24.7	164	302
August	30.7	23.0	26.9	29.3	18.7	24.0	245	292
September	32.1	22.9	27.5	31.4	19.1	25.2	179	139
October	30.3	22.1	26.2	34	17.2	25.6	115	21
November	32.3	19.0	25.6	29.3	14.7	22.0	18	4
December	31.4	15.7	23.6	31.2	11.8	21.5	6	0
Average	32.8	19.8	26.3	33.5	15.5	24.4	1196	1204

Note; Mae Sarieng province, average 10 years from 1994-2003 from Mae Sasieng hydrology station.

Tee Cha village, average 2 years from 2003-2005 from measurement in the village.

Table A-2 Soil pH of rotational shifting cultivation between difference *Macaranga denticulata* areas in Tee Cha Village.

Cropping year	*Macaranga* density	Depth 0-15 cm		Depth 15-30 cm	
		pH	SE	pH	SE
1998	Dense	5.51	0.04	5.20	0.05
	Sparse	5.43	0.01	5.30	0.06
1999	Dense	4.87	0.03	4.85	0.05
	Sparse	4.75	0.03	4.91	0.01
2000	Dense	5.16	0.02	4.90	0.02
	Sparse	5.06	0.04	4.98	0.02
2001	Dense	5.41	0.06	5.26	0.02
	Sparse	5.30	0.07	5.02	0.05
2002	Dense	5.29	0.05	5.32	0.05
	Sparse	4.97	0.06	4.91	0.06
2003	Dense	5.99	0.01	5.72	0.05
	Sparse	5.29	0.02	5.05	0.03
2004	Dense	5.06	0.01	5.14	0.05
	Sparse	4.93	0.01	4.84	0.04

Note: collected Oct 25, 2002, SE = Standard error

Table A-3 Organic matter from rotational shifting cultivation between different *Macaranga denticulata* area in Tee Cha village.

Cropping year	*Macaranga* density	Depth 0-15 cm		Depth 15-30 cm	
		OM (%)	SE	OM (%)	SE
1998	Dense	5.21	0.19	3.07	0.05
	Sparse	4.67	0.08	3.69	0.13
1999	Dense	9.24	0.04	7.51	0.13
	Sparse	9.04	0.15	6.86	0.09
2000	Dense	5.70	0.12	5.37	0.17
	Sparse	5.43	0.07	4.48	0.16
2001	Dense	6.02	0.16	4.54	0.16
	Sparse	5.75	0.18	4.73	0.09
2002	Dense	6.26	0.10	4.74	0.17
	Sparse	5.37	0.11	4.26	0.13
2003	Dense	7.55	0.07	4.45	0.14
	Sparse	6.70	0.13	3.83	0.15
2004	Dense	4.99	0.07	3.15	0.09
	Sparse	4.54	0.15	3.94	0.16

Note; collected Oct 25, 2002, SE = Standard error

Table A-4 Soil nutrient at 0-15 cm of rotational shifting cultivation between difference *Macaranga denticulata* area in Tee Cha village.

Cropping year	*Macaranga* density	N (%)	SE	P (ppm)	SE	K (ppm)	SE	Ca[a]	SE	Mg[a]	SE
1998	Dense	0.32	0.01	8.01	0.49	146.67	8.83	2.35	0.12	0.82	0.02
	Sparse	0.28	0.00	8.46	0.59	145.00	6.77	2.77	0.11	0.86	0.01
1999	Dense	0.43	0.01	5.20	0.13	140.00	10.27	0.43	0.05	0.49	0.02
	Sparse	0.42	0.02	4.72	0.69	110.00	2.96	0.19	0.04	0.27	0.03
2000	Dense	0.32	0.01	5.13	0.34	190.77	8.69	1.07	0.06	0.65	0.03
	Sparse	0.28	0.01	3.07	0.08	214.33	8.57	0.77	0.07	0.46	0.02
2001	Dense	0.29	0.02	9.25	0.56	149.93	8.52	1.91	0.12	0.80	0.02
	Sparse	0.29	0.02	7.51	0.70	186.33	7.98	1.86	0.08	0.77	0.02
2002	Dense	0.33	0.01	15.15	0.36	150.33	9.88	1.74	0.12	0.67	0.02
	Sparse	0.27	0.00	10.25	0.57	129.50	6.93	0.63	0.09	0.46	0.02
2003	Dense	0.41	0.01	9.83	0.49	186.00	4.37	4.19	0.10	0.99	0.02
	Sparse	0.36	0.02	7.48	0.22	200.33	6.15	1.60	0.09	0.67	0.03
2004	Dense	0.28	0.00	5.99	0.22	150.33	5.50	2.47	0.07	0.43	0.02
	Sparse	0.35	0.02	8.01	0.70	90.33	2.36	1.08	0.09	0.31	0.02

Note; a Ca=me 100 g soil^{-1}, SE = Standard error, collected Oct 25, 2002

Table A-5 Soil nutrient at 15-30 cm of rotational shifting cultivation between difference *Macaranga denticulata* area in Tee Cha village.

Cropping year	*Macaranga* density	N (%)	SE	P (ppm)	SE	K (ppm)	SE	Ca[a]	SE	Mg[a]	SE
1998	Dense	0.24	0.00	5.79	0.28	85.33	7.19	0.39	0.09	0.30	0.01
	Sparse	0.25	0.01	4.48	0.25	143.00	4.93	1.19	0.27	0.57	0.03
1999	Dense	0.33	0.01	2.86	0.34	127.00	2.31	0.19	0.02	0.20	0.02
	Sparse	0.32	0.01	2.49	0.18	92.00	3.51	0.16	0.03	0.18	0.02
2000	Dense	0.27	0.01	2.77	0.34	137.33	6.58	0.33	0.05	0.33	0.03
	Sparse	0.26	0.01	2.16	0.46	137.33	7.07	0.27	0.10	0.22	0.03
2001	Dense	0.23	0.01	5.73	0.62	133.83	7.55	0.71	0.07	0.63	0.02
	Sparse	0.24	0.01	3.93	0.50	144.67	7.07	0.83	0.06	0.67	0.03
2002	Dense	0.27	0.01	16.23	0.92	148.43	6.75	2.12	0.09	0.64	0.02
	Sparse	0.22	0.00	5.58	0.52	124.83	7.00	0.25	0.02	0.34	0.01
2003	Dense	0.28	0.02	3.80	0.66	191.33	4.17	3.55	0.06	0.99	0.01
	Sparse	0.26	0.01	8.41	0.45	123.33	7.03	1.28	0.03	0.24	0.03
2004	Dense	0.20	0.02	1.73	0.14	112.33	8.18	1.36	0.14	0.32	0.02
	Sparse	0.24	0.02	2.25	0.10	62.33	3.40	0.19	0.02	0.15	0.03

Note; a Ca=me 100 g soil^{-1}, SE = Standard error, collected Oct 25, 2002

Table A-6 Highland populations of Mae Hong Son province in 1987-2002.

Highland population	Years							
	1987	%	1992	%	1997	%	2002	%
Total	703,550	100.00	853,274	100.00	991,122	100.00	1,203,149	100.00
Mae Hong Son	83,090	11.81	102,465	12.01	115,018	11.60	127,503	10.60
Sop Moei district	18,898	2.69	19,720	2.31	22,997	2.32	29,162	2.42
Sop Moei subdistrict	3,811	0.54	4,163	0.49	4,643	0.47	6,660	0.55
Tee Cha village	104	0.01	120	0.01	128	0.01	157	0.01

Table A-7 Karen populations of Thailand in 1987-2002.

Karen population	Years							
	1987	%	1992	%	1997	%	2002	%
Total	295,350	100.00	353,110	100.00	353,574	100.00	438,131	100.00
Mae Hong Son	68,516	23.20	77,280	21.89	83,260	23.55	100,984	23.05
Sop Moei district	18,898	6.40	19,720	5.58	22,997	6.50	29,162	6.66
Sop Moei sub-district	3,811	1.29	4,163	1.18	4,643	1.31	6,660	1.52
Tee Cha village	104	0.04	120	0.03	128	0.04	157	0.04

Table A-8 Growth rate of highland population of Thailand in 1987-2002.

Highland population	Year 1987	Growth rate (%)		
		1987-1992	1987-1997	1987-2002
Total	703,550	21.28	40.87	71.01
Mae Hong Son	83,090	23.32	38.43	53.45
Sop Moei district	18,898	4.35	21.69	54.31
Sop Moei sub-district	3,811	9.24	21.83	74.76
Tee Cha village	104	15.38	23.08	50.96

Table A-9 Growth rate of Karen population of Thailand in 1987-2002.

Karen population	Year 1987	Growth rate (%)		
		1987-1992	1987-1997	1987-2002
Total	295,350	19.56	19.71	48.34
Mae Hong Son	68,516	12.79	21.52	47.39
Sop Moei district	18,898	4.35	21.69	54.31
Sop Moei sub-district	3,811	9.24	21.83	74.76
Tee Cha village	104	15.38	23.08	50.96

Appendix B. Photographs showing farmers' meeting for the management of traditional shifting cultivation in Tee Cha as presenting in Chapter 3.

(a)

(b)

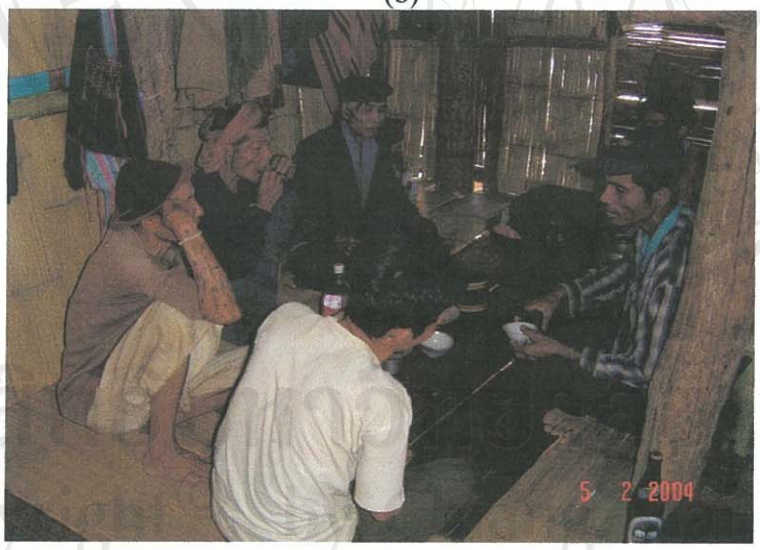
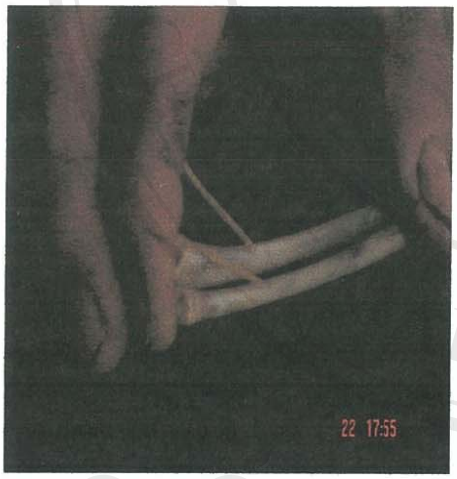


Figure B-1 Karen New Year cerebration in February each year (a) and farmers' discussion on next cropping cycle, suitable field for opening up and land allocation (b).

(a)

(b)



(c)

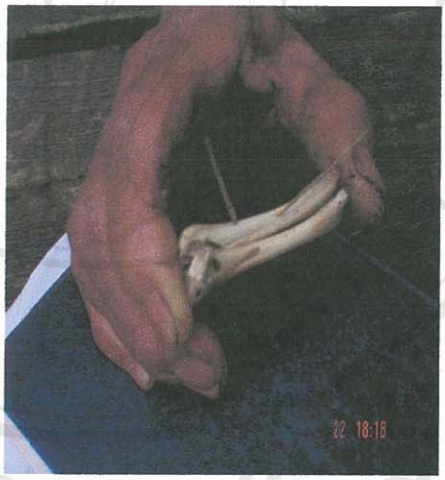
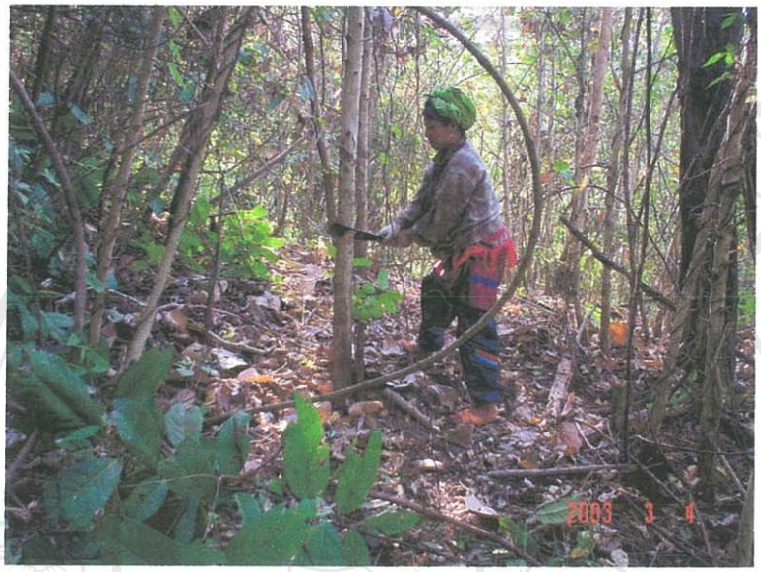


Figure B-2 Chicken bone divination: collection of wing bones after meals (a), positive out come (b) the bone pair are similar with observe sticks in the dimension or negative outcome (c) which influence on spiritual permission to cultivation the field. Field may be abandoned.

(a)



(b)

Figure B-3 Management of mature trees at slashing time; copping species cut off above ground level to allow productive regrowth from stump (a); lopping tree branches to allow rapid regeneration (b).

Figure B-4 Field condition 2-3 weeks before burning.

Figure B-5 Fire break construction before burning in order to prevent uncontrolled fire spread out side shifting cultivation filed on a large scale.

Figure B-6 Freshly burned field covered with ash.

Figure B-7 "Plae Tae Kir": it for land spirits to be performed after filed burning so that they will allow agricultural use of the land.

Figure B-8 Piling up un-burned residues for re-burning.

Figure B-9 Temporary shelter built in the field for resting.

Figure B-10 Some swidden crops are grown before rice seeding. Women of the household take care of the crops for household consumption and cooking.

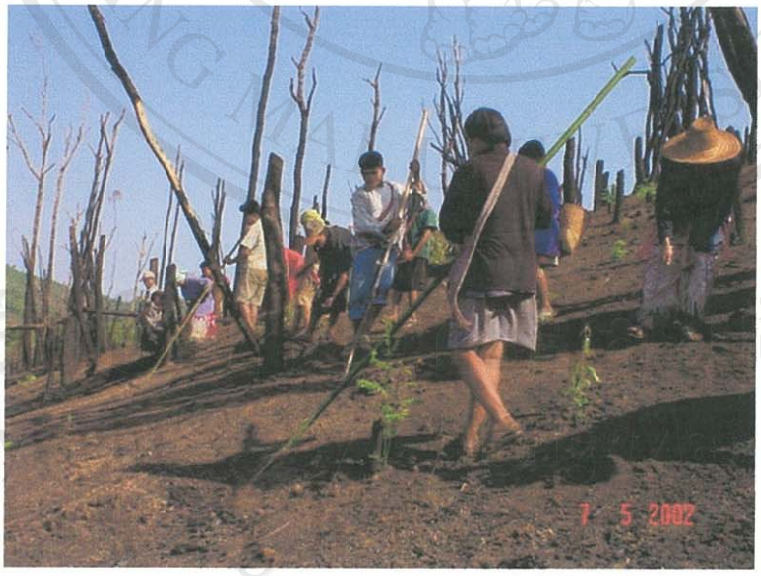


Figure B-11 Planting rice with digging stick by labour exchange in the village; up to 30 persons working in one field of 5-10 rai.

Figure B-12 Distance between hills averaging 20-30 cm..

Figure B-13 Rice seeds mixed with other swidden crop seeds and propagules.

Figure B-14 High seed rates (>30 seeds/hill) to ensure uniform stand establishment without any missing hills.

Figure B-15 "Bue Che Bao": the seven hills of upland rice. Left over seeds are not discarded but kept in bamboo cylinder above the square altar.

Figure B-16 Some swidden crops are grown after upland rice sowing.

Figure B-17 First weeding is mainly to remove young suckers from tree stumps.

Figure B-18 Establishment of upland rice after 1 month from sowing.

Figure B-19 *Macaranga* seedling with purple cotyledons and young leaves emerged in the rice field at about 2 months after rice sowing.

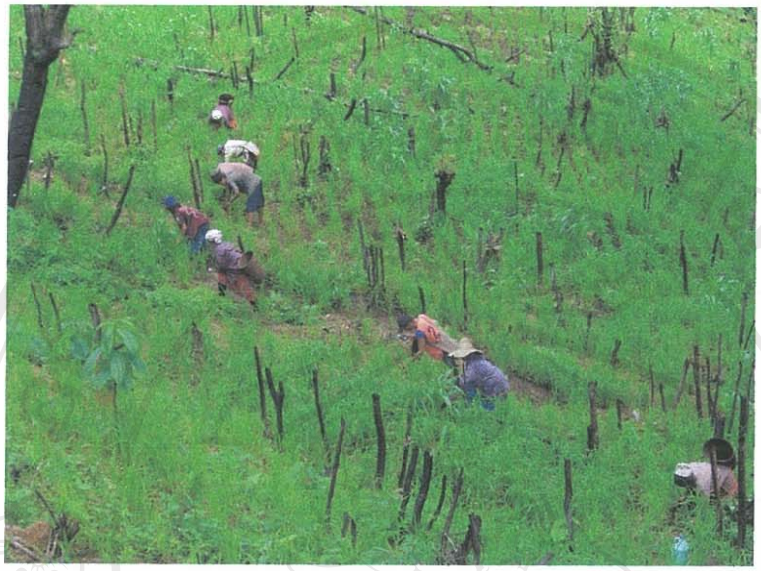


Figure B-20 Labour exchange for weeding in upland rice field.

Figure B-21 Bent knives: a locally made tool for weeding.

Figure B-22 Construction of fence traps for rat control.

Figure B-23 Soil insect could injure roots of upland rice severely. Occasional outbreak occurred recently.

Figure B-24 Diversity of swidden crops in upland rice field.

Figure B-25 Many products from swidden crops can be harvested early during the cropping season.

Figure B-26 "Lue Mee" is the rite for the fire spirits. Outsiders are not allowed to enter the field for at least 24 hrs. Rice seeds in this field could not be exchanged outside the clan.

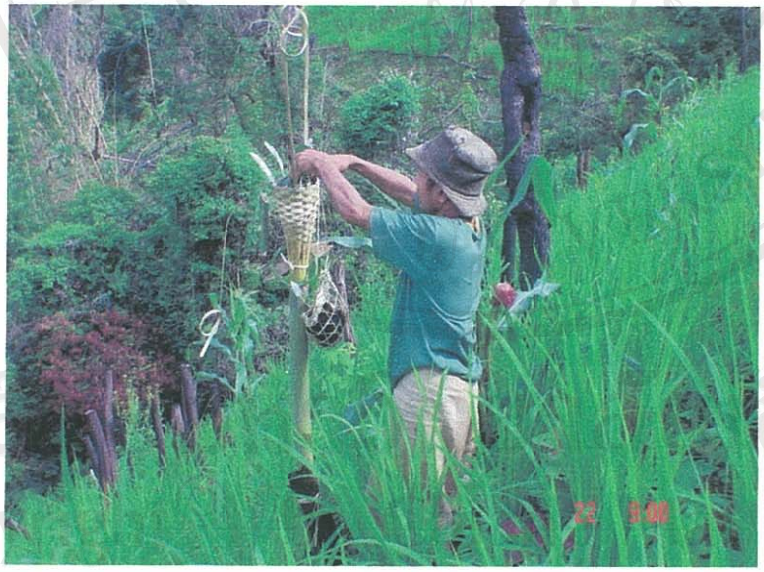


Figure B-27 "Zhe Kue" the rite for land spirit, offerings of chicken, rice and locally brewed alcohol. The ritual is believed to protect the rice crop from damages including pests and diseases.

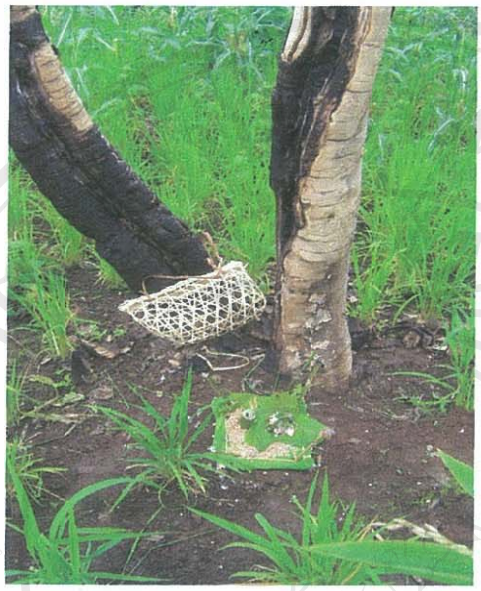


Figure B-28 "Zeng Za Sie" is the rite for tree spirit after planting finished. Live tree is selected for the ritual ceremony in late April to early May.

Figure B-29 Heading starts in September with early maturing variety.

Figure B-30 Distribution of *Macaranga* seedlings in upland rice at rice maturity: the dense populated site.

Figure B-31 Harvest starts in October with early maturity rice, followed by mid-season rice and late maturity in November.

Figure B-32 Drying upland rice in the field about 2-3 weeks before threshing.

Figure B-33 Rice threshing in big bamboo basket to avoid past harvest loss.

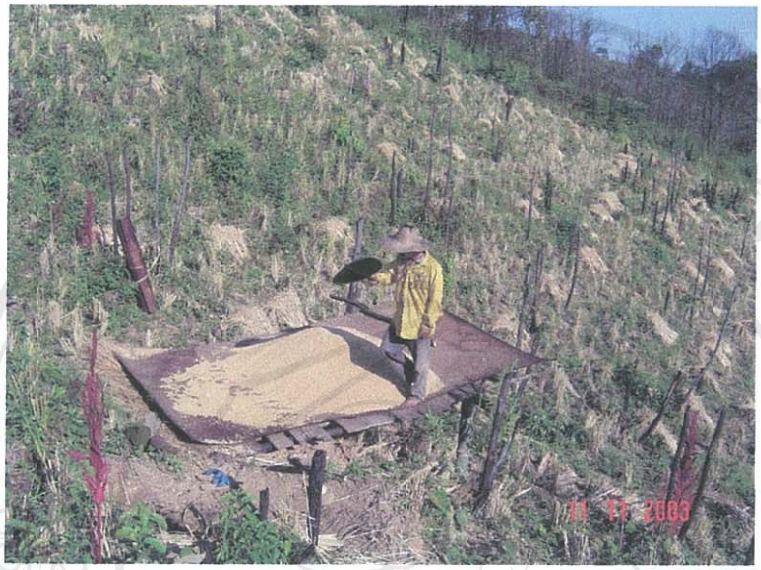


Figure B-34 Winnowing rice seed after threshing on bamboo mat.

Figure B-35 Rice straw piled up for animal (buffaloes and cattle) feed in dry season.

Figure B-36 Backpacking: transporting rice to the barn in the village.

Figure B-37 *Macaranga* seedling after 2 months of rice harvesting in densely populated area.

Figure B-38 Second year of regrowth with high abundance of *Macaranga* saplings.

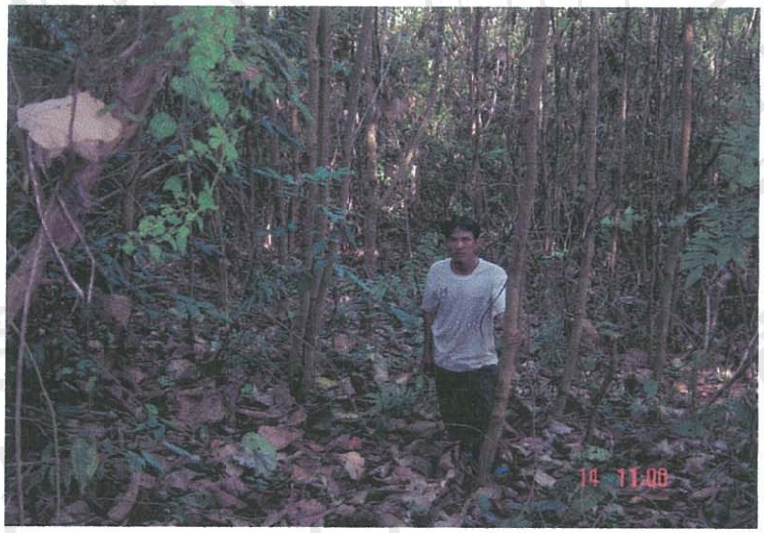


Figure B-39 Fallow field after 6 years of regrowth. In dense area of *Macaranga* with heavy leaf fall.

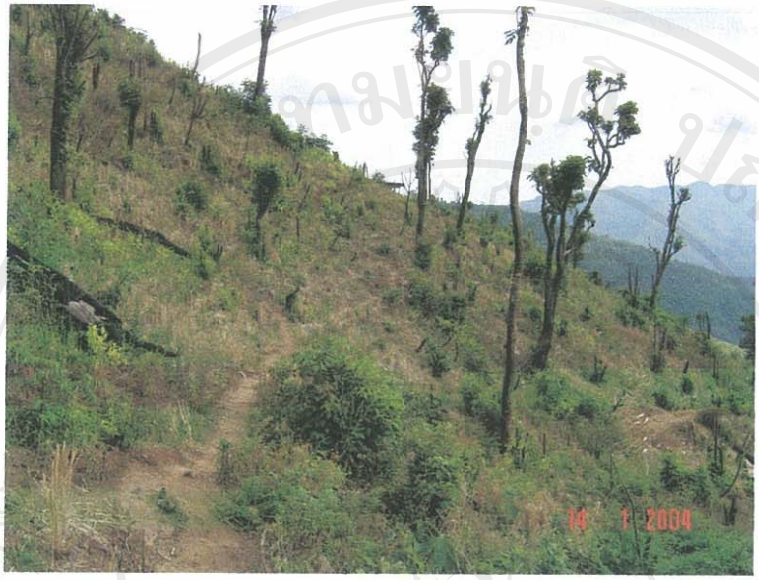


Figure B-40 Regeneration of trees and stumps after rice harvest, 1 st year of fallow regrowth.

Figure B-41 *Macaranga* seedling at rice harvest.

(a)

(b)

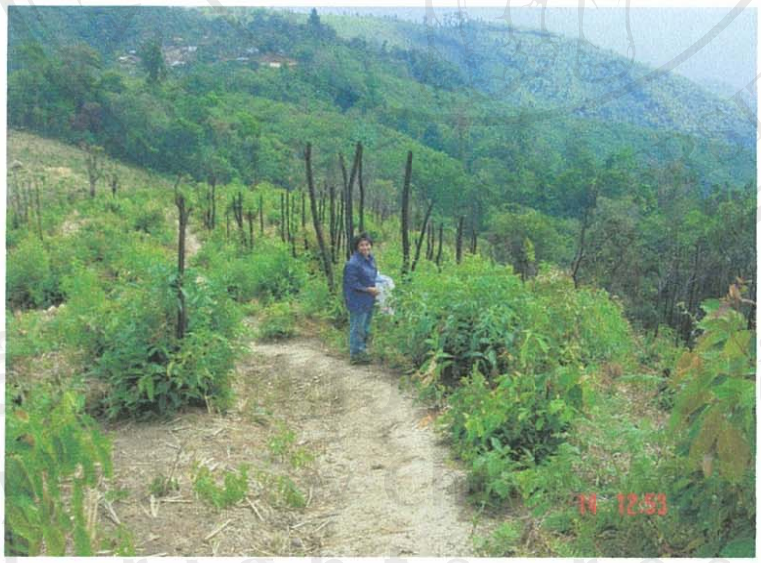


Figure B-42 Coppicing stumps after rice harvest; from above ground level (a) and from below ground level (b).

Appendix C: Farmers' methods for fallow management.

At slashing, farmers manage fallow trees differently depending on their pattern of growth and development.

a) For big climax trees, lopping the tree branches are practiced to promote fallow regeneration and at the some time allow adequate light penetration for underneath growth, especially upland rice crops.

b) For coppicing species, trees are cut at 0.5-1 meter above the ground level to ensure natural regenerate of young shoots and suckers after burning e.g. *Lithocarpus lindleyannus, Lithocarpus sootepensis, and Quercus ramsbottomii.*

c) For pioneer species, trees are cut higher at about 2-3 meter above ground level after burning. The method of cutting would serve as staking for diversity of that crop species with climbling habits such as wing bean, long bean. These pioneer species include *Macaranga denticulata,* and *Microcos peniculata.*

d) For herbaceous weeds, small shrubs, herbs, and small trees (below 1 m high, diameter 3 cm) were cut off at ground level to prevent their competition on upland rice. Residuals of these plants useful in the field for nature decomposition.

Appendix D. Methods of Tetra-Zolium (TZ) test for seed viability

There are five steps in a TZ test. Some steps may be omitted depending on the species of the seed. Analyst experience and preference may also affect the choice of method.

1. Preconditioning: Most seeds need to be imbibed with water before they are cut or prepared for the staining solution. Seeds are placed on moistened germination media (blotters or towels) overnight or for several hours.

2. Preparation: The imbibed seeds are then pierced or cut to expose the embryo to the staining solution. Some seeds require removal of covering structures like the fruit coat or the seed coat. Other species can simply be placed directly into the stain without any preparation.

3. Staining: The prepared seeds are placed into a TZ solution that has an appropriate TZ concentration for the species being tested and the preparation method chosen. Generally this is a one percent solution for whole or pierced seeds and a one-tenth percent solution for seeds that have been cut to expose the embryo. The time and temperature for staining are other variables that are species specific.

4. Preparation for evaluation: Again, this is species specific. Some dissection may be needed after staining to more clearly see the embryo structures. Lactic acid or glycerol may be used to "clear" seeds with dark seed coats if dissection is too difficult or time consuming. These clearing solutions lessen the chance of artifacts from the preparation method (2).

5. Evaluation: the analyst must know the seed structures and be able to evaluate staining patterns of the essential structures. Some parts of the seed naturally do not

stain. For example, seeds in the grass family have a non-staining endosperm. The stain color itself also has to be evaluated. A bluish purple color may indicate frost damage, while an orange red may indicate that the stain is improperly buffered. Staining may be uneven, due to the rate of solution uptake or the uneven metabolic activity in the different parts of the seed. The soundness and turgidity of the tissues are also examined. The many considerations for evaluation are discussed in handbooks and numerous technical papers in many scientific journals.

Table E-1. The species type of plant found that in the different fallow year in short rotational shifting cultivation of Tee Cha village.

Thai name	Karen name	Scientific name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
unidentified-(GC)-04	เนงคูเม่ง	unidentified-(GC)-04	unidentified-(GC)-04	U	0	0	0	0	0	0	1	1
unidentified-(GC)-06	เตงควี	unidentified-(GC)-06	unidentified-(GC)-06	U	0	0	0	0	0	0	0	0
unidentified-(GC)-07	โพบวีอดรี	unidentified-(GC)-07	unidentified-(GC)-07	U	0	0	0	0	1	0	0	0
unidentified-(GC)-08	โพลู่ซัง	unidentified-(GC)-08	unidentified-(GC)-08	U	0	0	0	0	1	0	0	1
หมามุ่ย	โผล่จือแซ	*Mucuna pruriens*	Papilionoideae	C	1	0	1	0	0	0	1	0
กูดดอย	กูดเกี๊ย,ก่ายบ่างซัง	*Pteris vittata*	Dryopteridaceae	F	1	0	1	0	0	1	0	0
เฟิร์น1	-	Fern-1	Fern-1	F	1	0	0	1	1	1	1	0
เฟิร์น2	-	Fern-2	Fern-2	F	1	0	0	1	1	1	0	0
ย่านลิเภา	ก้ายคู,ก่ายคุ	*Lygodium flxuosum*	Schizaeaceae	F	1	0	0	1	1	1	1	1
หญ้าปากควาย	-	*Digitaria violascens*	Gramineae	G	0	0	1	1	1	0	0	1
หญ้าคา	คียกะ	*Imperrata cylindica*	Gramineae	G	1	0	1	0	0	0	0	0
หญ้าขจรจบ	-	*Pennisetum pedicellatum*	Gramineae	G	0	1	0	0	0	0	0	0
กิ่ง	ก้าย	*Thysanolaena maxima*	Gramineae	G	1	1	0	0	0	0	0	1
หญ้าตีนนก	-	*Mollugo pentaphylla*	Molluginaceae	G	0	1	0	0	0	0	0	0
หญ้า-2	-	unidentified-15	unidentified-15	G	0	0	0	0	0	0	1	0
หญ้าปูนลวก	-	unidentified-17	unidentified-17	G	1	0	0	0	0	0	0	0
หญ้าหาน	-	unidentified-18	unidentified-18	G	1	0	0	0	0	0	0	0
unidentified-19	กังคุย	unidentified-19	unidentified-19	G	1	0	0	0	0	0	0	0

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
unidentified-20	แค่วคูโย๊ะดุ	unidentified-20	unidentified-20	G	1	0	0	0	0	0	0	0
unidentified-22	ดูก้ายดู	unidentified-22	unidentified-22	G	0	1	0	0	0	0	0	0
unidentified-24	นังกายคู	unidentified-24	unidentified-24	G	0	1	0	0	0	0	0	0
unidentified-25	นังคลั่งไล	unidentified-25	unidentified-25	G	0	1	0	0	0	0	0	0
unidentified-26	นังควยหมี่	unidentified-26	unidentified-26	G	0	1	0	0	0	0	0	0
unidentified-27	นังตะสีปะซอ	unidentified-27	unidentified-27	G	0	1	0	0	0	0	0	0
unidentified-28	นังทุยเขา	unidentified-28	unidentified-28	G	0	1	0	0	0	0	0	0
unidentified-29	นังน้อแดง	unidentified-29	unidentified-29	G	0	1	0	0	0	0	0	0
unidentified-30	นังเบเมะ	unidentified-30	unidentified-30	G	0	1	0	0	0	0	0	0
unidentified-31	นังปะทอ	unidentified-31	unidentified-31	G	0	1	0	0	0	0	0	0
unidentified-32	นังพลู	unidentified-32	unidentified-32	G	0	1	0	0	0	0	0	0
unidentified-33	นังมิซิ	unidentified-33	unidentified-33	G	0	1	0	0	0	0	0	0
unidentified-34	นังลือคา	unidentified-34	unidentified-34	G	0	1	0	0	0	0	0	0
unidentified-35	นังแวะด้าย	unidentified-35	unidentified-35	G	0	0	0	0	0	0	1	0
unidentified-36	นางจุบี	unidentified-36	unidentified-36	G	0	1	0	0	0	0	0	0
unidentified-38	โผ้ลจีบวย	unidentified-38	unidentified-38	G	0	1	0	0	0	0	0	0
unidentified-39	พลู้	unidentified-39	unidentified-39	G	0	1	0	0	0	0	0	0
หญ้าขนไก่	-	*Lepidagathis incurva*	Acanthaceae	H	0	0	0	0	0	0	0	0
ผักปราบ	-	*Commelina bengalensis*	Commelinaceae	H	1	0	0	0	0	0	0	0
สาบแร้ง	นางเนาะมือ	*Aguatum comyzoides*	Compositae	H	1	1	0	0	0	0	1	0

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
สาบเสือ	นางชะกุย/หน่อชะยะ	*Chromolaena odorata*	Compositae	H	1	1	1	1	1	1	1	1
ผักคราดหัวแหวน	-	*Sphaeranthus africanus*	Compositae	H	0	1	0	0	0	0	0	0
น้ำนมราชสีห์	-	*Euphorbia hirta*	Euphorbiaceae	H	0	1	0	0	0	0	0	0
งาขี้ม้อน	-	*Perilla frutesens*	Labiatae	H	1	0	0	0	0	0	0	0
ฝ้าย	-	*Gossypium herbaceum*	Malvaceae	H	1	0	0	0	0	0	0	0
Desmodium sp.-1	-	*Desmodium sp.-1*	Papilionoideae	H	0	0	0	0	0	0	0	0
Desmodium sp.-2	-	*Desmodium sp.-2*	Papilionoideae	H	0	0	0	0	0	0	0	0
งาขาว	-	*Sesamum orientale*	Pedaliaceae	H	1	0	0	0	0	0	0	0
ผักเผ็ด	ราทะลุ	*Monochoria vaginalis*	Pontederiaceae	H	1	0	0	0	0	0	0	0
ผักเผ็ดขมุ-1	วังไซ	*Monochoria vaginalis*	Pontederiaceae	H	1	1	0	0	0	0	0	0
ผักเผ็ดขมุ-2	-	*Monochoria vaginalis*	Pontederiaceae	H	1	0	0	0	0	0	0	0
พริกขี้หนู	-	*Capsicum frutescens*	Solanaceae	H	1	0	0	0	0	0	1	0
ยาสูบ	-	*Nicotians tabacum*	Solanaceae	H	1	0	0	0	0	0	0	0
มะแคว้ง ,มะเขือพวง	ชูแซ	*Solanum torvum*	Solanaceae	H	1	0	1	1	1	0	0	0
ชีฝรั่ง	กางบ่อง	*Eryngium foetidum*	Umbelliferae	H	1	0	0	1	0	0	0	0
หญ้า-3	-	unidentified-16	unidentified-16	H	0	0	0	0	0	0	0	0
หญ้า-4	-	unidentified-16	unidentified-16	H	0	0	0	0	0	0	0	0
unidentified-18	กะซังซีโพลี	unidentified-18	unidentified-18	H	0	1	0	0	0	0	0	0
unidentified-40	มิโยอีลายโพ	unidentified-40	unidentified-40	H	0	1	0	0	0	0	0	0
unidentified-41	ลีซอพลี	unidentified-41	unidentified-41	H	1	1	0	0	0	0	0	0

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
unidentified-42	เส่งซะเพ	unidentified-42	unidentified-42	H	0	1	0	0	0	0	0	0
unidentified-43	เส่งตาบี	unidentified-43	unidentified-43	H	0	1	0	0	0	0	0	0
unidentified-45	หมิโยจิ	unidentified-45	unidentified-45	H	1	0	0	0	0	0	0	0
หวายขม	-	*Calamus diepenhorsrtii*	Palmae	P	1	0	0	0	1	1	0	0
ค้อ	-	*Trachycarpus oreophilus*	Palmae	P	0	0	0	0	1	0	0	0
หนาด	โพแน	*Inula cuppa*	Compositae	S	1	1	1	0	0	0	0	0
ช้าแป้น	-	*Callicapa arborea*	Labiatae	S	0	0	0	0	0	1	0	1
ปิ้งขาว	โพะกลาย	*Clerodendrum infortunatum*	Labiatae	S	0	0	0	1	1	1	1	0
เขิงแข้งม้า	ทุคลุ	*Leea sp.*	Leeaceae	S	1	1	1	0	1	1	1	1
กระเจี๊ยบแดง	-	*Hibiscus sabdariffa*	Malvaceae	S	1	0	0	0	0	0	0	0
ขี้ครอก	-	*Urena lobata*	Malvaceae	S	1	1	0	0	0	0	0	0
อ้าหลวง	เซงซาเพละ	*Osbeckia watanae*	Melastomataceae	S	0	0	1	0	0	1	0	1
คราม	-	*Indigofera caloneura*	Papilionoideae	S	0	0	0	0	1	0	0	0
เข็มขาว	คุคุ	*Pavetta indica*	Rubiaceae	S	0	0	0	1	1	0	1	1
ข้าวสารป่า	โพบรือครี	*Pavetta tomentosa*	Rubiaceae	S	0	0	1	0	0	0	0	0
มะแว้ง	-	*Solanum sp.*	Solanaceae	S	1	0	0	0	0	0	0	0
เพกา	-	*Oroxylum indica*	Bignoniaceae	ST	1	0	0	1	1	1	1	1
เหมือดหลวง	รังคูระ	*Aporusa villosa*	Euphorbiaceae	ST	1	1	0	0	0	0	0	0
ไคร้มด	เซงทุลี	*Glichidion hirsutum*	Euphorbiaceae	ST	1	1	0	0	0	0	0	0
มันปลา	มังคูล้อง	*Glochidion sphaerogynum*	Euphorbiaceae	ST	1	1	1	1	1	1	0	1

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
ตองแตบ	ปะดะ	*Macaranga denticulata*	Euphorbiaceae	ST	1	1	1	1	1	1	1	1
Litsea sp.	-	*Litsea sp.*	Lauraceae	ST	0	0	0	0	0	0	0	0
ส้มป่อย	-	*Acacia concinna*	guminosae-mimosoide	ST	1	0	0	0	0	0	0	0
ตะมองคอง	แซงยายี	*Memecylon plebejum*	Melastomataceae	ST	1	0	0	0	0	0	0	1
มะขามแป	ไหนแซ	*Archidendron Jiringa*	Mimosaceae	ST	0	0	0	0	0	1	0	1
กันจ๊ำขาว	-	*Ardisia colorata*	Myrcinaceae	ST	0	1	0	0	0	0	0	0
ข้าวสาร	โพ๊ะขว่างโก้วย	*Maesa indica*	Myrsinaceae	ST	1	0	1	1	1	1	0	1
พุทราเลื้อย	-	*Zizyphus rugosa*	Rhamnaceae	ST	0	0	0	0	0	0	1	0
เค็ด	-	*Catunaregam tomentosa*	Rubiaceae	ST	1	0	0	0	0	0	0	0
แข้งกวาง1	โพ๊ะคว้าง	*Wendlandia paniculata*	Rubiaceae	ST	0	1	1	1	0	1	0	1
แข้งกวาง2	แข้งกวาง-2	*Wendlandia tinctoria*	Rubiaceae	ST	0	0	1	1	0	0	0	0
สีฟัน	-	*Harrisonia perforata*	Simaroubaceae	ST	0	0	0	0	0	0	1	0
เมี่ยงขน	-	*Camellia oleifera*	Theaceae	ST	0	0	0	0	1	0	0	0
เมี่ยงป่า	-	*Camellia pleurocapa*	Theaceae	ST	0	0	1	1	0	1	0	1
แมงเม่านก	แซงทวยหมี่คว้าง	*Eurya nitida*	Theaceae	ST	0	0	0	1	1	1	0	1
กอม	แพละ	*Microcos peniculata*	Tiliaceae	ST	1	0	1	1	1	1	1	1
unidentified-(GC)-01	กางแซ่งแม่ง	unidentified-(GC)-01	unidentified-(GC)-01	ST	0	0	0	0	0	0	1	1
unidentified-(GC)-02	แซงปูแก	unidentified-(GC)-02	unidentified-(GC)-02	ST	0	0	1	1	0	0	1	1
unidentified-(GC)-05	แหล่แม่แซ	unidentified-(GC)-05	unidentified-(GC)-05	ST	0	0	0	0	0	0	0	1
unidentified-04	ปิเดโอ	unidentified-04	unidentified-04	ST	1	0	0	0	0	1	0	1

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
unidentified-06	เห็ดข้างวาง	unidentified-06	unidentified-06	ST	0	0	0	0	1	0	0	0
unidentified-07	กุ้ยชง	unidentified-07	unidentified-07	ST	0	1	0	0	0	0	1	0
unidentified-11	ชีไร	unidentified-11	unidentified-11	ST	0	0	0	1	0	0	0	0
ป่าน	หมี่เคว	*Boehmeria sp.*	Urticaceae	ST	0	0	0	1	0	0	0	0
มะฮ่อ	-	*Spondias lakonensis*	Anacardiaceae	T	0	0	0	0	1	0	1	0
แคหางค่าง	ค่วย	*Fernandoa adenophylla*	Bignoniaceae	T	1	1	1	1	1	1	1	1
กาสะลองคำ	-	*Radermachera ignea*	Bignoniaceae	T	0	0	0	0	0	0	1	0
คูน	-	*Cassia fistula*	Caesalpinoideae	T	0	0	0	0	0	1	0	0
รกฟ้า	-	*Terminalia alata*	Combretaceae	T	0	1	0	0	0	0	0	0
แหน	-	*Terminalia bellirica*	Combretaceae	T	0	0	0	1	0	1	0	0
สมอไทย	-	*Terminalia chebula*	Combretaceae	T	0	0	1	0	0	0	1	0
ส้านหิง	คอง (คลอง)	*Dillenia parviflora*	Dilliniaceae	T	1	0	1	0	1	0	1	1
พะยอม	แซ่ว	*Shorea rogersiana*	Dipterocarpaceae	T	1	1	1	1	0	1	1	1
กล้วยฤาษี	เซงเปอแหน่	*Diospyros glandulosa*	Ebenaceae	T	0	0	1	1	0	0	0	1
มะมุ่น	ตะง้อ	*Elaeocarpus prunifolius*	Elaeocarpaceae	T	0	0	0	1	0	1	0	0
มะขามป้อม	ม่าจู่แส่	*Phyllanthus emblica*	Euphorbiaceae	T	1	1	1	1	1	1	1	1
ก่อเดือย	ซีผ่อมือ	*Castanopsis accuminatissima*	Fagaceae	T	0	0	1	0	1	1	0	1
ก่อด่าง	ซีไรทะ	*Lithocarpus lindleyannus*	Fagaceae	T	0	0	1	0	0	0	0	1
ก่อหัวหมู	ซีโก	*Lithocarpus sootepensis*	Fagaceae	T	1	1	1	1	1	1	0	1

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
ก่อ	-	*Lithocarpus sp.*	Fagaceae	T	0	1	0	0	0	0	0	0
ก่อหมาก	ก่อหมาก	*Quercus brandisiana*	Fagaceae	T	1	0	0	0	0	0	0	0
ก่อตลับ	เซที	*Quercus ramsbottomii*	Fagaceae	T	0	0	0	0	1	0	0	0
ติ้ว	ชุยนังเทะ	*Cratoxylum formosum*	Guttiferae	T	0	0	1	0	1	0	1	0
ดีหมี	ส่ะเข้า	*Gonocaryum lobbianum*	Icacinaceae	T	1	0	0	1	0	1	1	1
ค่าหด	เส่งเหน่จ้อ	*Engelhardtia spicata*	Juglandaceae	T	0	1	0	1	1	1	0	1
ฮ้อยจั่น	สบพัง	*Engelhardtia serrata*	Juglandaceae	T	0	0	1	0	1	1	0	0
สักขี้ไก่	-	*Prema tomentosa*	Labiatae	T	0	0	0	0	0	0	1	0
กาสามปีก	-	*Vitex peduncularis*	Labiatae	T	0	0	1	0	0	0	0	0
อบเชย	-	*Cinnamomum iners*	Lauraceae	T	0	0	0	1	1	0	0	0
ตะไคร้ต้น	ลิอูแซ	*Litsea cubeba*	Lauraceae	T	0	0	0	0	0	1	0	1
หมี่เหม็น	โม๊ะมู่	*Litsea glutinosa*	Lauraceae	T	1	0	0	1	1	1	0	1
มะดูกดง	เซงทุอังแพ	*Phoebe paniculata*	Lauraceae	T	0	0	1	0	1	1	0	1
ตองหอม	เส่งโกล้งโบ้ง	*Phoebe lanceolata*	Lauraceae	T	1	1	0	1	1	1	0	1
เสลาเขา	ชวาง	*Lagerstroemia sp.*	Lythraceae	T	0	0	0	1	1	0	1	0
ยมหอม	เรอย	*Toona ciliata*	Meliaceae	T	0	1	0	1	1	1	0	0
ก้างขี้มอด	-	*Albizea odoratissima*	Mimosaceae	T	0	0	1	1	1	0	0	0
ชะเนียง	-	*Archidendron jiringa*	Mimosoldeae	T	0	0	0	0	0	0	0	0
มะน๊อต	ดีแซ	*Ficus sp.*	Moraceae	T	1	1	0	0	0	0	1	0
มะห้า	-	*Syzygium albiflorum*	Myrtaceae	T	0	0	0	0	1	0	0	0

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
หว้า	-	*Syzygium cumini*	Myrtaceae	T	0	0	0	0	1	1	0	0
ชมพู่ป่า	มิหล่ง	*Syzygium megacarpum*	Myrtaceae	T	0	0	1	0	0	0	0	1
หว้า-1	-	*Syzygium sp.*	Myrtaceae	T	0	0	1	1	0	1	0	1
เคาะ	-	*Tristaniopsis burmanica*	Myrtaceae	T	0	0	1	0	0	0	0	0
คำไก่	เส่งคือเนะ (เส้งฮือไน้)	*Olea salicifolia*	Oleaccac	T	1	1	1	1	0	1	1	1
เหมือดคนตัวเมีย	เซงโกเบง	*Helicia excelsa*	Proteaceae	T	0	0	1	0	1	1	0	1
กว้าว	-	*Haldina cordifolia*	Rubiaceae	T	1	1	0	0	0	0	1	0
ตุ้มเต็น	ถู	*Duabanga graniflora*	Sonnerratiaceae	T	0	1	0	1	1	0	1	1
ปอมื่น	ช้างถั่ม	*Pterospermum sp.*	Sterculiaceae	T	1	0	0	1	1	0	0	0
เหมือดใบหอก	-	*Symplocos sp.*	Symplocaceae	T	0	0	0	0	0	0	0	0
ทะโล้	หี่ยซ๊ะ	*Schima wallichii*	Theaceae	T	1	0	1	0	0	1	1	1
ไก๋หลวง	ตะสีเชแซว	*Ternstroemia sp.*	Theaceae	T	0	0	0	1	0	0	1	0
ปอยาบใบหยัก	-	*Colona floribunda*	Tiliaceae	T	0	0	0	1	1	0	1	0
หางนก	-	*Grewia lacei*	Tiliaceae	T	0	0	0	1	1	0	0	1
unidentified-(GC)-09	ช้างแผ้สิมุ	unidentified-(GC)-09	unidentified-(GC)-09	T	0	0	0	0	1	0	1	0
ชุดายแต	ชุดายแต	unidentified-(GC)-10	unidentified-(GC)-10	T	0	0	1	0	0	0	0	0
unidentified-(GC)-11	ตะชีดู	unidentified-(GC)-11	unidentified-(GC)-11	T	0	0	0	0	1	0	0	0
unidentified-01	unidentified-01	unidentified-01	unidentified-01	T	0	0	0	0	0	0	0	1
unidentified-02	ปะคังที	unidentified-02	unidentified-02	T	0	0	0	0	0	0	1	1
unidentified-03	ปะตู	unidentified-03	unidentified-03	T	1	1	1	1	1	1	1	1

Thai name	Karen name	Science name	Familly	Type	Fallow year							
					0	1	2	3	4	5	6	>8
unidentified-05	โพะเก่งลัง	unidentified-05	unidentified-05	T	0	0	0	0	0	0	0	1
unidentified-10	ชางซีดู	unidentified-10	unidentified-10	T	1	0	0	0	0	0	0	0
unidentified-12	เซงทุสี	unidentified-12	unidentified-12	T	0	0	1	0	0	0	0	0
unidentified-13	เซงแหนแก้	unidentified-13	unidentified-13	T	0	0	1	0	1	1	1	0
ไม้เยี่ยวควาย	-	unidentified-14	unidentified-14	T	1	0	0	0	0	0	1	0
unidentified-23	แทะสีโผล่	unidentified-23	unidentified-23	T	1	0	0	0	0	0	0	0
unidentified-37	บายเซ	unidentified-37	unidentified-37	T	0	1	0	0	0	0	0	0
unidentified-44	เส่งตารู	unidentified-44	unidentified-44	T	0	1	0	0	0	0	0	0
สะแกวัลย์	-	*Combretum punctatum*	Combretaceae	WC	0	0	0	0	0	0	1	0
เครือมะเมื่อย	เกล้ามือแซ	*Gnetum montanum*	Gnetaceae	WC	0	0	0	1	0	0	0	0
เครือ-บรงบัง	เบลงบังเซ-เครือ	*Embelia ribes*	Myrsinaceae	WC	1	1	1	0	0	1	0	1
ปี้เครือ	ซีคลั่ง	*Dalbergia velutina*	Papilionoideae	WC	1	1	1	1	1	1	1	1
ก๋าวเครือ	-	*Millettia extensa*	Papilionoideae	WC	1	0	0	0	0	0	0	0
เครือไหล	-	*Millettia pachycarpa*	Papilionoideae	WC	1	0	0	0	0	1	1	0
unidentified-(GC)-03	แทะมัง-เครือ	unidentified-(GC)-03	unidentified-(GC)-03	WC	0	0	0	0	0	0	0	1
unidentified-08	ซิลอง-เครือ	unidentified-08	unidentified-08	WC	0	1	0	0	0	0	0	0
unidentified-09	เซงดี-เครือ	unidentified-09	unidentified-09	WC	0	0	0	1	0	0	0	1
unidentified-21	ซุนี	unidentified-21	unidentified-21	WC	1	1	0	0	0	0	1	0
unidentified-46	ฮ้อแน้	unidentified-46	unidentified-46	WC	1	1	0	0	0	0	0	0
					67	67	60	71	83	86	95	53

notes;

Total species = 176

U = unknown
C = Climber
F = Fern
G = Grass
H = Herb
P = Palm
S = Shrub
ST = Small Tree
T = Tree
WC = Woody Climber

1 = Found in that year

0 = Not found in that year

Table E-2 The useful of plants species in the shor rotational shifting cultivation of Tee Cha village.

Thai name	Karen name	Scientific name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
unidentified-(GC)-04	เนงคูเม่ง	unidentified-(GC)-04	unidentified-(GC)-04	u	N						
unidentified-(GC)-06	เตงคว๊	unidentified-(GC)-06	unidentified-(GC)-06	u	N						
unidentified-(GC)-07	โพบวีอดรี	unidentified-(GC)-07	unidentified-(GC)-07	u	N						
unidentified-(GC)-08	โพคู่ชัง	unidentified-(GC)-08	unidentified-(GC)-08	u	N						
หมามุ่ย	โผล่จือแซ	*Mucuna pruriens*	Papilionoideae	C	N						
เฟิร์น1	-	Fern-1	Fern-1	F	N						
เฟิร์น2	-	Fern-2	Fern-2	F	N						
ย่านลิเภา	ก้ายคู,ก่ายคุ	*Lygodium flxuosum*	Schizaeaceae	F	Y	X		X			X
กูดดอย	กูดเกี๊ย,ก่ายบ่างชัง	*Pteris vittata*	Dryopteridaceae	F	N						
หญ้าปากควาย	-	*Digitaria violascens*	Gramineae	G	N						
หญ้าคา	คียกะ	*Imperrata cylindica*	Gramineae	G	Y		X				
หญ้าตีนนก	-	*Mollugo pentaphylla*	Molluginaceae	G	N						
หญ้าขจรจบ	-	*Pennisetum pedicellatum*	Gramineae	G	N						
กง	ก้าย	*Thysanolaena maxima*	Gramineae	G	Y						X
หญ้า-2	-	unidentified-15	unidentified-15	G	N						
หญ้าปูนลวก	-	unidentified-17	unidentified-17	G	N						
หญ้าหาน	-	unidentified-18	unidentified-18	G	N						
unidentified-19	กังคุย	unidentified-19	unidentified-19	G	Y	X					X

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
unidentified-20	แค่วคูโย๊ะดุ	unidentified-20	unidentified-20	G	Y	X					
unidentified-22	ดูก้ายดู	unidentified-22	unidentified-22	G	N						
unidentified-24	นังกายคู	unidentified-24	unidentified-24	G	N						
unidentified-25	นังคลังไล	unidentified-25	unidentified-25	G	N						
unidentified-26	นังควยหมี	unidentified-26	unidentified-26	G	Y			X			
unidentified-27	นังตะสีปะซอ	unidentified-27	unidentified-27	G	Y			X			
unidentified-28	นังทุยเซา	unidentified-28	unidentified-28	G	N						
unidentified-29	นังน้อแดง	unidentified-29	unidentified-29	G	N						
unidentified-30	นังเบเมะ	unidentified-30	unidentified-30	G	Y	X		X			
unidentified-31	นังปะทอ	unidentified-31	unidentified-31	G	N						
unidentified-32	นังพลู	unidentified-32	unidentified-32	G	N						
unidentified-33	นังมิชิ	unidentified-33	unidentified-33	G	N						
unidentified-34	นังลือคา	unidentified-34	unidentified-34	G	N						
unidentified-35	นังแวะด้าย	unidentified-35	unidentified-35	G	Y					X	
unidentified-36	นางจุบี	unidentified-36	unidentified-36	G	Y			X			
unidentified-38	โผ้ลจีบวย	unidentified-38	unidentified-38	G	Y			X			
unidentified-39	พลู้	unidentified-39	unidentified-39	G	Y					X	
หวายขม	-	*Calamus diepenhorsrtii*	Palmae	P	Y	X					X
ค้อ	-	*Trachycarpus oreophilus*	Palmae	P	N						
สาบแร้ง	นางเนาะมือ	*Aguatum comyzoides*	Compositae	H	Y			X			

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
พริกขี้หนู		*Capsicum frutescens*	Solanaceae	H	Y	X					
สาบเสือ	นางชะกุย/หน่อชะยะ	*Chromolaena odorata*	Compositae	H	Y			X			
ผักปราบ	-	*Commelina bengalensis*	Commelinaceae	H	Y	X					
Desmodium sp.-1	-	*Desmodium sp.-1*	Papilionoideae	H	N						
Desmodium sp.-2	-	*Desmodium sp.-2*	Papilionoideae	H	N						
ชีฝรั่ง	กางบ่อง	*Eryngium foetidum*	Umbelliferae	H	Y	X					
น้ำนมราชสีห์	-	*Euphorbia hirta*	Euphorbiaceae	H	Y			X			
ฝ้าย	-	*Gossypium herbaceum*	Malvaceae	H	Y						X
หญ้าขนไก่	-	*Lepidagathis incurva*	Acanthaceae	H	N						
ผักเผ็ด	ราทะลุ	*Monochoria vaginalis*	Pontederiaceae	H	Y	X					
ผักเผ็ดขมุ-1	วังไซ	*Monochoria vaginalis*	Pontederiaceae	H	Y	X		X			
ผักเผ็ดขมุ-2	-	*Monochoria vaginalis*	Pontederiaceae	H	Y	X					
ยาสูบ	-	*Nicotians tabacum*	Solanaceae	H	Y	X		X			X
งาขี้ม้อน	-	*Perilla frutesens*	Labiatae	H	Y	X					X
งาขาว	-	*Sesamum orientale*	Pedaliaceae	H	Y	X					X
มะแคว้ง ,มะเขือพวง	ชูแซ	*Solanum torvum*	Solanaceae	H	Y	X					
ผักคราดหัวแหวน	-	*Sphaeranthus africanus*	Compositae	H	Y	X					
หญ้า-3	-	unidentified-16	unidentified-16	H	N						
หญ้า-4	-	unidentified-16	unidentified-16	H	N						
unidentified-18	กะชังชีโพล์	unidentified-18	unidentified-18	H	Y	X					

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
unidentified-40	มิโยอีลายโพ	unidentified-40	unidentified-40	H	Y	X					
unidentified-41	ลีซอพลี	unidentified-41	unidentified-41	H	Y	X					
unidentified-42	เส่งชะเพ	unidentified-42	unidentified-42	H	Y	X					
unidentified-43	เส่งตาบี	unidentified-43	unidentified-43	H	N						
unidentified-45	-	unidentified-45	unidentified-45	H	N						
ช้าแป้น	-	*Callicapa arborea*	Labiatae	S	N						
ปิ้งขาว	โพะกลาย	*Clerodendrum infortunatum*	Labiatae	S	Y						X
กระเจี๊ยบแดง	-	*Hibiscus sabdariffa*	Malvaceae	S	Y	X					X
คราม	-	*Indigofera caloneura*	Papilionoideae	S	Y						X
หนาด	โพแน	*Inula cuppa*	Compositae	S	Y	X					X
เขิงแข้งม้า	ทุคลุ	*Leea sp.*	Leeaceae	S	Y			X			
อ้าหลวง	เซงชาเพละ	*Osbeckia watanae*	Melastomataceae	S	Y	X		X			
เข็มขาว	คุคุ	*Pavetta indica*	Rubiaceae	S	N						
ข้าวสารป่า	โพบรือครี	*Pavetta tomentosa*	Rubiaceae	S	N						
มะแว้ง	-	*Solanum sp.*	Solanaceae	S	Y	X					
ขี้ครอก	-	*Urena lobata*	Malvaceae	S	N						
ส้มป่อย	-	*Acacia concinna*	Leguminosae-mimosoideae	ST	Y	X					X
เหมือดหลวง	รังคูระ	*Aporusa villosa*	Euphorbiaceae	ST	Y	X					
มะขามแป่	ไหนแซ	*Archidendron Jiringa*	Mimosaceae	ST	Y	X					X

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
กันจ้ำขาว	-	*Ardisia colorata*	Myrcinaceae	ST	N						
ป่าน	หมี่เคว	*Boehmeria sp.*	Urticaceae	ST	N						
เมี่ยงขน	-	*Camellia oleifera*	Theaceae	ST	Y				X		
เมี่ยงป่า	-	*Camellia pleurocapa*	Theaceae	ST	Y	X			X		
เค็ด	-	*Catunaregam tomentosa*	Rubiaceae	ST	N						
แมงเม่านก	แซงทวยหมี่คว้าง	*Eurya nitida*	Theaceae	ST	Y			X			
ไคร้มด	เซงทุลี	*Glichidion hirsutum*	Euphorbiaceae	ST	Y	X	X				
มันปลา	มังคูล้อง	*Glochidion sphaerogynum*	Euphorbiaceae	ST	Y	X	X		X		
สีฟัน	-	*Harrisonia perforata*	Simaroubaceae	ST	Y						X
Litsea sp.	-	*Litsea sp.*	Lauraceae	ST	N						
ตองแตบ	ปะดะ	*Macaranga denticulata*	Euphorbiaceae	ST	Y		X		X	X	
ข้าวสาร	โพ๊ะขว่างโก้วย	*Maesa indica*	Myrsinaceae	ST	Y		X			X	
ตะมองคอง	แซงยายี	*Memecylon plebejum*	Melastomataceae	ST	Y		X			X	
กอม	แพละ	*Microcos peniculata*	Tiliaceae	ST	Y	X	X		X	X	
เพกา	-	*Oroxylum indica*	Bignoniaceae	ST	Y	X		X			
unidentified-(GC)-01	กางแซ่งแม่ง	unidentified-(GC)-01	unidentified-(GC)-01	ST	N						
unidentified-(GC)-02	แซงปู่แก	unidentified-(GC)-02	unidentified-(GC)-02	ST	Y			X			
unidentified-(GC)-05	แหล่แม่แซ	unidentified-(GC)-05	unidentified-(GC)-05	ST	N						
unidentified-04	ปิเดโอ	unidentified-04	unidentified-04	ST	Y			X			
unidentified-06	เห็ดข้างวาง	unidentified-06	unidentified-06	ST	N						

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
unidentified-07	กุ้ยชง	unidentified-07	unidentified-07	ST	Y	X	X			X	
unidentified-11	ชิไร	unidentified-11	unidentified-11	ST	Y		X			X	X
แข้งกวาง1	โพ๊ะคว้าง	*Wendlandia paniculata*	Rubiaceae	ST	Y	X	X			X	
แข้งกวาง2	แข้งกวาง-2	*Wendlandia tinctoria*	Rubiaceae	ST	Y					X	
พุทราเลื้อย	-	*Zizyphus rugosa*	Rhamnaceae	ST	Y	X					
กำจี้มอด	-	*Albizea odoratissima*	Mimosaceae	T	Y					X	
ชะเนียง	-	*Archidendron jiringa*	Mimosoideae	T	Y					X	
คูน	-	*Cassia fistula*	Caesalpinoideae	T	Y	X		X			
ก่อเดือย	ชีผ่อมือ	*Castanopsis accuminatissima*	Fagaceae	T	Y	X	X			X	
อบเชย	-	*Cinnamomum iners*	Lauraceae	T	Y	X					X
ปอยาบใบหยัก	-	*Colona floribunda*	Tiliaceae	T	Y					X	
ติ้ว	ชุยนังเทะ	*Cratoxylum formosum*	Guttiferae	T	Y					X	
ส้านหิ่ง	คอง (คลอง)	*Dillenia parviflora*	Dilliniaceae	T	Y	X			X		
กล้วยฤาษี	เซงเป่อแหน่	*Diospyros glandulosa*	Ebenaceae	T	Y		X	X		X	
ตุ้มเต็น	กู	*Duabanga graniflora*	Sonnerratiaceae	T	Y	X		X			
มะมุ่น	ตะง้อ	*Elaeocarpus prunifolius*	Elaeocarpaceae	T	Y	X	X	X		X	
ฮ้อยจั่น	สบพัง	*Engelhardtia serrata*	Juglandaceae	T	Y	X					
ค่าหด	เส่งเหน่จ้อ	*Engelhardtia spicata*	Juglandaceae	T	Y					X	
แคหางค่าง	ค่วย	*Fernandoa adenophylla*	Bignoniaceae	T	Y	X					
มะน๊อต	ดีแซ	*Ficus sp.*	Moraceae	T	Y	X					X

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
ดีหมี	ส่ะเข้า	*Gonocaryum lobbianum*	Icacinaceae	T	Y		X			X	
หางนก	-	*Grewia lacei*	Tiliaceae	T	Y					X	
กว้าว	-	*Haldina cordifolia*	Rubiaceae	T	Y					X	
เหมือดคนตัวเมีย	เซงโกเบง	*Helicia excelsa*	Proteaceae	T	Y		X		X	X	
เสลาเขา	ชวาง	*Lagerstroemia sp.*	Lythraceae	T	Y		X			X	
ก่อด่าง	ชีไรทะ	*Lithocarpus lindleyannus*	Fagaceae	T	Y	X			X		
ก่อหัวหมู	ชีโก	*Lithocarpus sootepensis*	Fagaceae	T	Y	X			X		
ก่อ-?	-	*Lithocarpus sp.*	Fagaceae	T	Y		X			X	
ตะไคร้ต้น	ลิอูแซ	*Litsea cubeba*	Lauraceae	T	Y	X				X	
หมี่เหม็น	โม๊ะมู่	*Litsea glutinosa*	Lauraceae	T	Y		X				X
คำไก่	เส่งคือเนะ (เส้งฮือไน้)	*Olea salicifolia*	Oleaccac	T	Y		X			X	
มะดูกดง	เซงทุอังแพ	*Phoebe paniculata*	Lauraceae	T	Y		X			X	
ตองหอม	เส่งโกส้งโบ้ง	*Phoebe lanceolata*	Lauraceae	T	Y		X			X	
มะขามป้อม	ม่าจู่แส่	*Phyllanthus emblica*	Euphorbiaceae	T	Y	X					
สักขี้ไก่	-	***Prema tomentosa***	Labiatae	T	Y		X			X	
ปอมื่น	ช้างถั่ม	*Pterospermum sp.*	Sterculiaceae	T	Y		X			X	
ก่อหมาก	ก่อหมาก	*Quercus brandisiana*	Fagaceae	T	Y	X					
ก่อตลับ	เซที	*Quercus ramsbottomii*	Fagaceae	T	Y		X			X	
กาสะลองคำ	-	***Radermachera ignea***	Bignoniaceae	T	Y					X	
ทะโล้	หี่ยซ๊ะ	*Schima wallichii*	Theaceae	T	Y		X			X	

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
พะยอม	แซ่ว	*Shorea rogersiana*	Dipterocarpaceae	T	Y	X	X			X	
มะฮ่อ	-	*Spondias lakonensis*	Anacardiaceae	T	Y					X	
เหมือดใบหอก	-	*Symplocos sp.*	Symplocaceae	T	Y		X			X	
มะห้า	-	*Syzygium albiflorum*	Myrtaceae	T	Y		X			X	
หว้า	-	*Syzygium cumini*	Myrtaceae	T	Y					X	
ชมพู่ป่า	มิหล่ง	*Syzygium megacarpum*	Myrtaceae	T	Y	X	X			X	
หว้า-1	-	*Syzygium sp.*	Myrtaceae	T	Y					X	
รกฟ้า	-	*Terminalia alata*	Combretaceae	T	Y					X	
แหน	-	*Terminalia bellirica*	Combretaceae	T	Y					X	
สมอไทย	-	*Terminalia chebula*	Combretaceae	T	Y					X	
ไก่หลวง	ตะสีเชแซว	*Ternstroemia sp.*	Theaceae	T	Y					X	
ยมหอม	เรอย	*Toona ciliata*	Meliaceae	T	Y		X			X	
เคาะ	-	*Tristaniopsis burmanica*	Myrtaceae	T	Y					X	
unidentified-(GC)-09	ช้างแผ้สิมุ	unidentified-(GC)-09	unidentified-(GC)-09	T	Y	X					X
ชุดายแต	ชุดายแต	unidentified-(GC)-10	unidentified-(GC)-10	T	Y			X			
unidentified-(GC)-11	ตะชีดู	unidentified-(GC)-11	unidentified-(GC)-11	T	Y	X					
unidentified-01	unidentified-01	unidentified-01	unidentified-01	T	Y					X	
unidentified-02	ปะคังที	unidentified-02	unidentified-02	T	Y					X	
unidentified-03	ปะตู	unidentified-03	unidentified-03	T	Y			X		X	
unidentified-05	โพะเก่งลัง	unidentified-05	unidentified-05	T	Y		X			X	

Thai name	Karen name	Science name	Familly	Type	Objective of used						
					Uesd	Fo	C	M	Fe	Fu	O
unidentified-10	ชางชีดู	unidentified-10	unidentified-10	T	Y	X					
unidentified-12	เซงทุสี	unidentified-12	unidentified-12	T	Y	X	X			X	
unidentified-13	เซงแหนแก้	unidentified-13	unidentified-13	T	Y	X	X			X	X
ไม้เยี่ยวควาย	-	unidentified-14	unidentified-14	T	Y					X	
unidentified-23	แทะสีโผล่	unidentified-23	unidentified-23	T	Y					X	
unidentified-37	บายเซ	unidentified-37	unidentified-37	T	Y					X	
unidentified-44	เส่งตารู	unidentified-44	unidentified-44	T	Y					X	
กาสามปีก	-	*Vitex peduncularis*	Labiatae	T	Y		X			X	
สะแกวัลย์	-	*Combretum punctatum*	Combretaceae	WC	N						
ปี้เครือ	ชีคลั่ง	*Dalbergia velutina*	Papilionoideae	WC	Y			X			
เครือ-บรงบัง	เบลงบังเซ-เครือ	*Embelia ribes*	Myrsinaceae	WC	Y	X					
เครือมะเมื่อย	เกล้ามือแซ	*Gnetum montanum*	Gnetaceae	WC	Y	X		X			
ก๋าวเครือ	-	*Millettia extensa*	Papilionoideae	WC	Y						
เครือไหล	-	*Millettia pachycarpa*	Papilionoideae	WC	Y						X
unidentified-(GC)-03	แทะมัง-เครือ	unidentified-(GC)-03	unidentified-(GC)-03	WC	N						
unidentified-08	ชิลอง-เครือ	unidentified-08	unidentified-08	WC	Y			X			X
unidentified-09	เซงดี-เครือ	unidentified-09	unidentified-09	WC	N						
unidentified-21	ชุนี	unidentified-21	unidentified-21	WC	Y						X
unidentified-46	ฮ้อแน้	unidentified-46	unidentified-46	WC	Y						X

Notes; by interviwe farmers in the Tee Cha village year 2004

Used	U = unknown	C = Climber
N = No used	F = Fern	G = Grass
Y = Used	H = Herb	P = Palm
	S = Shrub	ST = Small Tree
	T = Tree	WC = Woody Climber

Appendix F

Table F-1 Farmer's name in Tee Cha village

	Name (Karen)	Name (Thai)
1	Mayo	มะโย
2	Takae	ทะแค
3	Thongdee	ทองดี
4	Daloy	ดาลอย
5	Pongsawan	พรสวรรค
6	Nayo	นะโย
7	Kaewloy	แก้วลอย
8	Pawda	พอดา
9	Krawchui	เกาะชุ่ย
10	Tanee	ธานี
11	Luyo	ลุโย
12	Kuiloy	ขลุ่ยลอย
13	Saucha	โชะวา
14	Ducare	ดุแค
15	Liyo	ลิโย
16	Peeda	ปรีดา
17	Tucare	ตุแค
18	Lar	หล้า
19	Suyo	สุโย
20	Dachui	ดะโชย
21	Dipo	ดิโพ
22	Padikae	พะดิแก
23	Murkur	มือกือ
24	Pho	พอ
25	Nopporn	นพพร
26	Kika	กิกะ
27	Caredo	แคดู
28	Daeng	แดง
29	Chaemui	แคะมุย
30	Dichai	ดิแช
31	Kan	คาน
32	Mongchai	มนชัย
33	Nalong	ณรงค์
34	Pabai	พะแบะ
35	Nujae	นุแจ

Table F-2 Local rice varieties name

Rice type	Local names (Karen)	Local names (Thai)
Glutinous (ข้าวเหนียว)	Pa Ai Khu Phae	ปะอ้ายคูเพ่
	Pa Ai Ki Kal	ปะอ้ายกี่ก่าย
	Pa Ai Goal	ปะอ้ายโกล
	Pa Ai Chai	ปะอ้ายชาย
	Pa Ai Chair	ปะอ้ายแชร์
Non-glutinous (ข้าวเจ้า)	Bue Bang	บือบ้าง
	Bue Gau	บือกั้วะ
	Bue Goal	บือโกล
	Bue Kee	บือกี่
	Bue Paw Low	บือปอลอ
	Bue Pho Lae	บือโพแล
	Bue Mue Ta Bong	บือมือตาบ้อง
	Bue Chu	บือชู
	Bue Khu Koo	บือคุคู่
	Bue Tho Lae	บือโทแล
	Bue Mue	บือมือ
	Bue Care	บือแค

Table F-3 Local swidden crops name

No.	Common name or local name (Karen)	Common name or local name (Thai)	Scientific name
1	Chili	พริก	*Capsicum sp.*
2	Glutinous corn	ข้าวโพด (พื้นเมือง)	*Zea mays*
3	Taro	เผือก	*Colocasia antiqurum Schott*
4	Cassava	มันสำปะหลัง	*Manihot esculenta Crantz.*
5	Sweet potato (white)	มันเทศ (ขาว)	*Ipomea batatas*
6	Sweet potato (red)	มันเทศ (แดง)	*Ipomea batatas*
7	Yam bean	มันแกว	*Pacchyrhizus crosus*
8	Yams	มันแกว	*Diocorea alata L.*
9	Pumpkin	ฝักทอง	*Cucurbita pepo L.*
10	Pumpkin	ฝักทอง	*Cucurbita pepo L.*
11	Winter melon (long)	ฟักเขียว (ยาว)	*Benincasa hispida*
12	Winter melon (round)	ฟักเขียว (กลม)	*Benincasa hispida*
13	Cucumber	แตงกวา	*Lagenaria bucantha*
14	Small Cucumber	แตงกวา (เล็ก)	*Cucurbita pepo*
15	Squashes	น้ำเต้า	*Luffa acutangula*
16	Gourd	บวบ	-
17	Bitter gourd	บวบขม	-
18	Local eggplant (long)	มะเขือ (ยาว)	*Solanum sp.*
19	Local eggplant (round)	มะเขือ (กลม)	*Solanum sp.*
20	Egg plant	มะเขือ	*Solanum spp.*
21	Egg plant (brittle)	มะเขือขม	-
22	Lima bean	ถั่วลิมา	-
23	Back bean	ถั่วดำ	-
24	Centro	ถั่วลาย	*Centrosema pubescens*
25	Long bean	ถั่วฝักยาว	-
26	Winged bean (long)	ถั่วพู (ยาว)	*Psophocarpus tetragonolobus*
27	Winged bean(short)	ถั่วพู (สั้น)	*Psophocarpus tetragonolobus*
28	Okra	กระเจี๊ยบเขียว	*Hibicus escutentusl*
29	Roselle	กระเจี๊ยบแดง	*Hibicus Sabdariffa*
30	Ginger	ขิง	*Zingiber officinata Rose*
31	Lemon grass	ตะไคร้	*Cymbopogon citratus*
32	Millet	ข้าวฟ่าง	*Seteria italica (L.) Beauv*
33	Local millet	ข้าวฟ่างพื้นเมือง	-

34	White seeded sesame	งาขาว	*Sesame indicum L.*
35	Back seeded sesame	งาดำ	-
36	Small seeds sesame	งาขี้หมอด	*Perilla frutescens Britt.*
37	Cotton	ฝ้าย	*Gossypium arboreum*
38	Phak E-Leun	ผักอีหลิน	*Isodon ternifolius*
39	Lettuce	ผักสลัด	*Brassica sp.*
40	Tobacco	ยาสูบ	*Nicotiana tobacum*
41	Leaf mustard	ผักกาดพื้นเมือง	*Brassica juncea*
42	Shallot	ต้นหอม	*Allium cepa L.*
43	Onion	หอมแดง	-
44	Coriander	ผักชี	*Foeniculum vulgare*
45	Tomato	มะเขือเทศ	*Lycopersicum sp.*
46	Rape	ผักกาดก้านขาว	*Brassica napus L.*
47	Job's tear	ลูกเดือย	*Coix lachryma-jobi L.*
48	Small Job's tear (long)	ลูกเดือยเล็ก (ยาว)	*Coix puellarum*
49	Small Job's tear (round)	ลูกเดือยเล็ก (กลม)	*Coix puellarum*
50	Krang Kui	กร่างดู	-
51	Wan sai	หว่างซาย	-
52	Burmese marigold	ดอกหงอกไก่	*Cosmos caudatus HBK.*
53	Marigold	ดอกดาวเรือง	*Tagetes patula L.*
54	Safflower	ดอกทานตะวันพื้นเมือง	*Carthamus tinctorius L.*
55	Po nete	ดอกโพแน	-
56	Dawk Talom	ดอกบานไม่รู้โรย	*Gomphrena globasa L.*

Curriculum vitae

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Narit Yimyam, Benjavan Rerkasem and Kanok Rerkasem. 2005. Fallow regeneration and soil fertility restoration for upland rice production in shifting cultivation of Northern Thailand. A poster presented at the Thailand Research Fund Meso Groups Meeting, October 26-27, 2005. Thailand.

Narit Yimyam, Benjavan Rerkasem and Kanok Rerkasem. 2005. Shifting Cultivation in Northern Thailand: Land Use Changes and Alternative Management for Sustainable Production and Improvement of Rural Livelihoods. A paper presented at workshop on "Shifting Agriculture, Environmental Conservation and Sustainable Livelihoods of Marginal Mountain Societies" October, 6-10 2005. Guwahati, Assam, India.

Narit Yimyam, Somchit Youpensuk, Benjavan Rerkasem and Kanok Rerkasem.

2005. The role of mycorrhizal fungi and *Macaranga denticulate* symbiosis in maintaining productivity of rice in shifting cultivation with shorter fallow. A paper presented at conference "Conservation and sustainable management of belowground biodiversity" June, 21-23 2005. Kerala forest research institute, Thrissur India.

N. Yimyam, K. Rerkasem, S. Lordkaew and B. Rerkasem. 2004. Associated growth of Macranga denticulate and abuscular mycorrhizal fungi in traditional rotational shifting cultivation of Northern Thailand. A poster presented at the 20th pacific Science Congress, Mach 17-21 2004. Bangkok, Thailand.

Yimyam, N., Rerkasem, K. and Rerkasem, B. 2003. Fallow enriching with pada (*Macaranga denticulata* (Bl.) Muell. Arg.) trees in rotational shifting cultivation in Northern Thailand. Agroforestry Systems. 57: 79-86.

Narit Yimyam, Benjavan Rerkasem, Kanok Rerkasem, and Richard J. Hobbs. 2004. Dynamics of *Macaranga denticulata* regeneration in short rotational shifting cultivation in Northern Thailand. A poster presented at The 2004 Annual conference of the Ecological Society of Australia. December, 7-10 2003. The University of Adelaide South Australia.

Narit Yimyam, Warapong Boooma, Anothai Sirabanchongkran, Benjavan Rerkasem and Kanok Rerkasem. 2003. Diversity of Cultivated Plants in Rotational Shifting Cultivation of the Pwo Karen Community in Northern Thailand. A poster presented at the Thailand Research Fund Meso Groups Meeting, October 26-27, 2003. Chiangmai University, Chiang Mai, Thailand.

Kanok Rerkasem, Charal Thong-Ngarn, Chawalit Korsamphan, ***Narit Yimyam*** and Benjavan Rerkasem. 2002. Intensification and diversification of land use in the highlands of northern Thailand. In: Brookfield, H., Padoch, C., Parsons, H. and Stocking, M. (Eds.). Cultivating Biodiversity: Understanding, Analysing & Using Agricultural Diversity Intermediate Technology Development Group (ITDG). London. 292 p.

Rerkasem. K., ***Yimyam, N.***, Korsamphan, C., Thong-ngam, C., and Rerkasem, B. 2002. Agrodiversity lessons in mountain land management. Mountain Research and Development. Vol. 22 No.1 p 4-9.

Thong-ngam, C., Areethamm, T., Kaewpha, P., Thepsarn, S., ***Yimyam, N.***, Korsamphan, C. and Rerkasem K. 2002. Scaling-Up PLEC Demonstration Site for National Pilot Programme: A Case Example of Hong Ngua Village in Northern Thailand. Paper for samina PLEC N&V 19.April 23-27, 2002.

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Fallow enrichment with pada (*Macaranga denticulata* (Bl.) Muell. Arg.) trees in rotational shifting cultivation in northern Thailand

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Abstract

Shifting cultivators in Thailand widely attribute the maintainance of crop productivity to pada (*Macaranga denticulata* (Bl.) Muell. Arg.), rotation cycles having become much shorter than the customary 10–20 years. This paper examines the use of pada in a 7-year rotation on an acid soil with low available soil P (2–4 mg kg^{-1} by Bray II). Dense pada patches in 7-year-old fallow averaged 43 tons ha^{-1} of above ground biomass, 20% more than sparse patches. The biomass in dense pada contained disproportionately more P, K, Ca and Mg (34%, 92%, 80% and 107% more, respectively) than in sparse pada patches. Slashing and burning 7-year-old fallow with dense pada produced a subsequent rice yield that was three time that with sparse pada. Rice grown after dense pada had been slashed and burned after three years yielded less than one third of that after a full 7-year rotation. It is, as yet, unclear how rice yield in dense pada patches is enhanced in the full 7-year rotation. Nutrient concentrations in the mature rice were generally either the same or higher in the sparse than dense pada patches. In dense pada patches rice accumulated twice to four times as much nutrients as in sparse pada patches, and a much larger fraction of the nutrients was stored in the fallow. Uptake of nutrients in the sparse pada patches may have been limited by some factor that either governs availability of the nutrients released by burning or depressing rice growth and so its nutrient demand.

Introduction

Rotational shifting cultivation has been shown to be a productive and sustainable form of land use in mountainous areas where land is sufficiently plentiful to allow a fallow period of 10–20 years (Kunstadter 1978). Population pressure combined with an increasing demand for conservation (from watersheds, erosion control, carbon sequestration to biodiversity) by society at large, however, have made certain that this luxury of very long fallows is now no longer an option for most shifting cultivators in Southeast Asia (Rerkasem and Rerkasem 1995) and elsewhere. Considerable interest, therefore, has arisen in approaches that might maintain crop productivity with shorter fallow. Numerous efforts, especially in Africa, have gone into identification of trees and other plants as fallow–enriching species (e.g., Tarawali (1991) and Kwesiga and Coe (1994), Mafongoya and Nair (1997), Kaya and Nair (2001)). This paper reports on the use of a local tree called *pada* for fallow improvement that has helped to maintain upland rice yield at reasonable levels of 2 to 4 Mg ha^{-1} on a seven years rotation.

Pada (*Macaranga denticulata* (Bl.) Muell. Arg.) is well known for its fallow-enriching property amongst the various ethnic groups who make a living on rotational shifting cultivation in northern Thailand. It is known as *Teen Tao* amongst the *Khamu* and *H'tin* who populate the northeastern mountains, on the border with Laos. *Pada* is the name in *Skaw Karen* (Thailand's largest minority group, now concentrated along

the western border with Myanmar), while the *Pwo Karen* call it *Letha*. The *Lua* (who are believed to have been the dominant group in the region until about a thousand years ago) call it *Tong Coab*. The *Akha* (a group not known to practice rotational shifting cultivation in Thailand) call the tree *Loom Piah*. Amongst lowland *Thai* it is variously called *Tong Taeb, Tong Tao, Tao Maew, Por Khee Haed* or *Bai Hoo Chang*. Pada is a small evergreen tree of the Euphorbiaceae family, that can reach 19 m in height and up to 40 cm in diameter at breast height. *Macaranga* is a relatively large genus of pioneer species (Whitmore 1982). Some 80 species have been identified in Africa and 200 in the Eastern Tropics, although not all are pioneer species. *M. gigantea* and *M. kurzii* also occur in the study village of Huai Tee Cha, but according to farmers pada is the only species with a fallow-improving property. The presence of pada in the fallow is believed to be responsible for maintaining productivity of upland rice in the shorter rotation. This study set out to measure the effect of pada on nutrient accumulation and upland rice yield in farmers' fields in a village where rotational shifting cultivation is still the dominant cropping system.

Materials and methods

The study was conducted in the rotational shifting cultivation fields of the village of Huai Tee Cha (19°78′ N, 93°84′ E), Sob Moei District, Mae Hong Son Province, about 250 km southwest of Chiang Mai. The soil is reddish clay loam. Before commencing plant and soil sampling, we took 30 days to become acquainted with the system by interviewing farmers and extensive field walks. The communally managed shifting cultivation area was divided into fields that are cropped in different years, designated by the year in which rice was last grown (Figure 1). According to the villagers this rotation has taken place for about 200 years, ever since Tee Cha was settled from a neighbouring village. A preliminary study of vegetation composition of the fallow forests was carried out in February and March (the village's normal slashing and burning season) of 2000. Trees were recognized as pada or 'others'. From areas with high and low density pada (defined in collaboration with farmers and designated dense and sparse pada), density of pada and other species was determined in three replicates of 10 × 10 m quadrats. Dominant 'other' species were *Microcos peniculata, Lithocarpus sp., Phoebe lanceolata* and *Glochidion sphaerogynum* (Further information about vegetation composition as well as tree density, biomass and nutrient contents of fallow areas with different ages will be reported elsewhere).

Mature fallow before slashing and burning

As field 1994/2000 was to be slashed and burned it was sampled for biomass and nutrient contents. Dry weight (sub-samples dried to constant weight at 80 °C) of the above ground live biomass, divided into pada and others, and litter were determined. The samples, whole plants in case of pada and others, were analyzed for N, P, K, Ca and Mg. Before burning soil samples were taken from the same area at 0–30 and 30–60 cm for determination of pH (water, 1:1), organic matter content (Walkley-Black), available P (Bray II, Wanatabe and Olsen (1962)), K, Ca and Mg (1 N NH_4OAc pH7).

The upland rice crop

A detailed study of the upland rice was carried out on the crop belonging to one farmer, Nopporn. At 30 days from sowing, samples (whole tops) of ten rice plants each were taken from the sparse and dense pada area for determination of N, P, K, Ca and Mg. At the same time soil samples were taken for determination of fertility characteristics at 0–30 and 30–60 cm depth. At maturity, samples of the rice crop were taken in 2 × 5 m quadrats from the sparse and dense pada areas. In addition, 1 × 1 m samples of rice at maturity were also taken from sparse and dense pada areas from five other farmers in the same village. The rice samples were threshed in the field and separated into grain and straw. Grain yield was determined after 3 days of sun drying (to water content of about 12%), straw yield was measured after drying for 48 hours at 80 °C. Sub-samples from Nopporn's field were also evaluated for the yield components, i.e. number of hills m^{-2}, plants $hill^{-1}$, tillers $hill^{-1}$, panicles $plant^{-1}$ and 1,000 seed weight, and analyzed for N, P, K, Ca and Mg in the grain and straw.

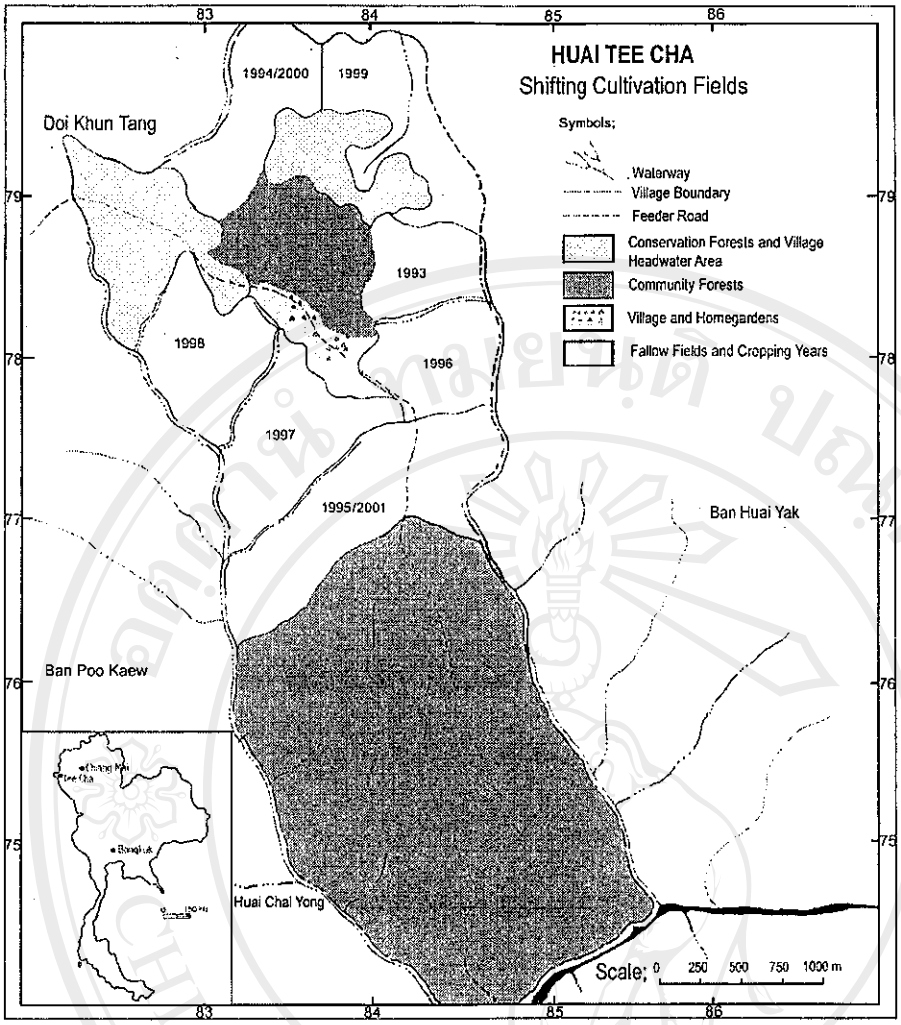

Figure 1. Rotational shifting cultivation fields of Huai Tee Cha village in northern Thailand indicating year of cropping.

Results and discussion

Fallow biomass and nutrient content

After seven years of regrowth (the rice cropping year is considered year 1 of regrowth, as fallow regeneration begins with upland rice emergence) above ground biomass averaged 43 Mg ha^{-1} in dense pada patches, about 20% more than that in sparse patches (Table 1). Pada contributed more than half of the biomass in the dense patches, and only 39% in sparse patches. There was also considerably more litter in dense pada patches. The above ground biomass in dense pada patches contained 536 kg N, 38 kg P, 253 kg K, 132 kg Ca and 46 kg Mg ha^{-1}. This was 10% more N, 34% more P, 92% more K, 80% more Ca and 107% more Mg than that in the sparse pada patches (Table 2). In the mature fallow of 8 years rotation in the village of Pa Pae (18°15′ N 98°3′ E) in the same vicinity where no pada was found (Sabhasri 1978) 143 kg N, 16 kg P and 176 kg K ha^{-1} were reported to have accumulated in the 63 t of above ground biomass (Zinke et al. 1978). The slight difference in total biomass N between sparse and dense pada patches in this study is accounted for by other species, which in sparse pada contributed as much N as pada in the dense pada patches. Pada was clearly crucial to the accumulation of extra P, K, Ca and Mg, though not so much for N. The higher amount of nutrients accumulated in dense pada came largely from

Table 1. Total aboveground biomass in the fallow vegetation after seven years of regeneration of a rotational shifting cultivation system in northern Thailand.

	Sparse pada	Dense pada	Significant difference by t-test
	Mg ha^{-1}		
Pada	9.4	22.2	$p < 0.01$
Other species	21.6	14.2	$p < 0.01$
Litter	4.7	6.4	$p < 0.01$
Total	35.7	42.8	$p < 0.05$

Table 2. Above ground nutrient contents in the fallow vegetation after seven years of regeneration of a rotational shifting cultivation system in northern Thailand.

Vegetation type	Nutrient element	Dense pada	Sparse pada	Significant difference
		Nutrient content (kg ha^{-1})		
Pada	N	289	131	$p < 0.01$
	P	21	6	$p < 0.01$
	K	97	32	$p < 0.01$
	Ca	72	21	$p < 0.01$
	Mg	10	6	$p < 0.05$
Other	N	191	297	$p < 0.01$
	P	12	18	$p < 0.05$
	K	118	85	$p < 0.01$
	Ca	28	36	NS
	Mg	23	6	$p < 0.01$
Litter	N	56	59	NS
	P	5	4	NS
	K	38	14	$p < 0.01$
	Ca	32	16	$p < 0.05$
	Mg	13	10	NS
Total	N	536	488	$p < 0.01$
	P	39	29	$p < 0.05$
	K	253	132	$p < 0.01$
	Ca	132	73	$p < 0.01$
	Mg	46	22	$p < 0.01$

pada in the case of P, pada and litter in the case of Ca, and from other species as well as pada and litter in the case of K and Mg. Pada roots were found to be associated with a diversity (genera and species) and abundance of arbuscular mycorrhizal fungi, both in the number of spores found in the rhizosphere and in root colonization (Youpensook et al. (in press)).

Soil fertility characteristics before slashing and burning and under rice

The study site was on a very acid soil, with pH 4.3 (1:1 water) before burning (Table 3). As others have previously shown (e.g., Nye and Greenland (1964) and Sanchez (1976)), burning clearly had a strong liming effect. Thirty days after rice sowing, pH of the surface soil measured 4.8, and slightly less deeper in the soil profile. Soil organic matter content declined slightly from around 4% before burning to 3.6% by the time rice was 30 days old. The first rainfalls of the season that germinated the rice may have contributed to this decline by stimulating microbial activity. Available soil P was generally very low at 2–4 mg kg^{-1}. There were significant but very small effects of pada density and burning on available P. The highest P value (Bray II) was 4.3 mg kg^{-1}, in dense pada patches after burning, which is very low indeed compared with about 12 mg kg^{-1} considered to be suffi-

Table 3. Fertility characteristics of the soil of the study area, in a rotational shifting cultivation system in northern Thailand, before burning and 30 days after rice sowing.

Pada density	Time	pH (1:1 water)	Organic matter (%)	P	K	Ca	Mg
				(mg kg^{-1})		(meq 100 g^{-1})	
Depth, 0–30 cm							
Sparse	Before[a]	4.30	3.96	2.23	133	0.53	0.27
	After[b]	4.79	3.60	3.34	181	0.64	0.48
Dense	Before	4.26	4.19	2.62	148	0.78	0.65
	After	4.83	3.84	3.70	198	0.75	0.67
Depth, 30–60 cm							
Sparse	Before	4.29	3.87	1.53	107	0.38	0.13
	After	4.41	3.43	3.00	156	0.47	0.49
Dense	Before	4.24	3.97	2.02	110	0.56	0.37
	After	4.58	3.73	4.29	178	0.59	0.50
Significant effects by analysis of variance							
Effects	Pada	NS	NS	*	NS	*	*
	Time	*	*	*	*	NS	NS
	Depth	NS	NS	NS	*	*	*
PxT, TxD, PxT, PxTxD		NS	NS	NS	NS	NS	NS

a) Before burning; b) After burning and 30 days from rice sowing

cient (Sanchez 1976). There was no significant difference in soil pH, organic matter and extractable K content between dense and sparse pada patches (Table 3). On the other hand, dense pada was associated with 47% more extractable Ca and twice to three times as much extractable Mg than in the sparse pada patches.

Pada establishment

As upland rice germinated after the first rains, pada emerged in thick pink carpets among the rice. Farmers do not treat pada as weeds, they are not routinely removed when the rice is weeded by hand. Thinning may be done where the density is considered too high and some attempts are sometimes made to transplant seedlings to low density areas. At rice maturity, about six months after sowing, and when pada had reached almost 1.5 m height, the number of pada averaged about 7 plants m^{-2} in dense patches, twice that in sparse patches (Table 4). In the fields cropped in different years, there was a trend of pada density decrease with fallow age (data not shown). In the 1995 field (slashed and burned in 2001), dense pada patches averaged 0.4 pada-tree m^{-2}, and 0.1 pada-tree m^{-2} in sparse patches. Since these are a fraction of the numbers of pada seedlings in the first year, the problem of low pada density must have been associated with survival of the seedlings rather than recruitment.

Table 4. Density of trees, pada and other species, after 6 months and 7 years in a rotational shifting cultivation system in northern Thailand.

Species	Pada density	Trees/m^2	
		6 months[a]	7 years[b]
Pada	Sparse	3.27 ± 0.32	0.10 ± 0.01
	Dense	6.60 ± 0.12	0.42 ± 0.02
Others†	Sparse	ND	0.12 ± 0.01
	Dense	ND	0.21 ± 0.01

a) At rice harvest ND = not determined, very few other plants at this time; b) Before slashing and burning for the next crop, the rice year is year 1 of regrowth; † Major species included *Microcos peniculata, Lithocarpus sp., Phoebe lanceolata* and *Glochidion sphaerogynum*. Values are mean ± standard errors of three replicates.

Upland rice nutrition and yield

Rice plants at one month in dense pada contained N and K at significantly higher concentrations than those in sparse pada patches (Table 5). No significant difference was found in the concentration of P, Ca and Mg. Based on published data (Reuter et al. 1997), the rice crop at 30 days was deficient in N and K in sparse pada area, and deficient in P in both sparse and dense pada area.

Table 5. Nutrient concentration in the upland rice (whole tops) at 30 days from sowing, in areas following pada at low and high densities in a rotational shifting cultivation system in northern Thailand.

Concentration (%)	Sparse pada	Dense pada
N	2.76[a]	4.06[b]
P	0.29	0.32
K	3.60[a]	4.99[b]
Ca	0.19	0.26
Mg	0.22	0.24

a) For same nutrient element, different letters designate significant difference by LSD ($p < 0.05$).

In 7-year rotation, rice grain yield in the dense pada area determined from detailed measurements in a field belonging to one farmer, averaged 2.57 Mg ha^{-1}, three times that in the sparse pada area (Table 6). Similar effects of pada density on the rice grain and straw yield were observed in 7-year rotation fields belonging to five other farmers (Table 7). The higher yield in dense pada patches was associated largely with a higher number of panicles and percentage of fertile tillers, and to a less extent higher plant density and number of tillers $hill^{-1}$ (Table 8). The effect was clearly cumulative, requiring more than three years of fallow.

How did high pada density increase the rice yield? Rice grown in dense pada patches that were slashed and burned after three years of fallow yielded only 0.74 Mg ha^{-1} of grain (Table 6). Clearly, the higher rice yield was not due to some pre-existing condition in the dense pada patches. As discussed above, the growth of rice at 30 days in sparse pada patches may have been limited by N and K deficiency, and more severely by P deficiency. By maturity, the concentration of N and Mg in the rice grain and P in both grain and straw were higher in the sparse than in the dense pada area (Table 9). The concentration of straw N and Mg and grain K were not different between rice in sparse and dense pada area. Straw K was the only case of nutrient concentration in rice in dense pada exceeding that in the sparse area. Critical K deficiency concentrations have been reported at 0.4% in the grain and 1% in the straw (Reuter et al. 1997). Compared with these, K deficiency is not indicated by the the grain K concentration at 0.45% and straw K at 1.91% in the rice in the sparse pada patches.

At maturity, the rice crop accumulated twice as much N, P, Ca and Mg and four times K in the dense as in the sparse pada patches (Table 9). However, the amount of N, P and K taken up by the rice crop accounted for a much smaller fraction of the nutrients accumulated above ground in 7-year old-fallow in the sparse (4%, 15% and 16%, for N, P and K, respectively) than in the dense pada patches (9%, 25% and 30%, respectively). The rice Ca and Mg uptake relative to the nutrient in fallow biomass were somewhat closer between sparse (13% for Ca; 5% for Mg) and dense (15% and 6%, respectively) pada patches. Although much of the above ground N in the fallow would have been lost with burning, most of the P, K, Ca and Mg could be assumed to remain in the ash. Much more nutrients would have been present in the root zone of rice than was taken up by the rice crop. The much smaller fraction of fallow accumulated P and K taken up by rice in sparse compared with dense pada patches suggested that the uptake of these nutrients was limited by some factor(s). Such a factor may limit uptake through demand by depressing growth and yield of the rice or through availability of the nutrients released by burning. Further explanation is not yet possible from data obtained so far.

This paper has shown that upland rice in a 7-year rotation yielded three times as much grain with pada at 0.42 trees m^{-2} as with 0.10 trees m^{-2} in the fallow, and that the effect was not due to some pre-existing condition in the high pada patches. The factor most immediately relevant to the farmers of Huai Tee Cha, and others who similarly depend on rotational shifting cultivation for their living in the mountainous region of mainland Southeast Asia, is if and how this effect of dense pada may be transferred to areas with sparse or no pada. The answer may be dependent on identification of (a) factors that are limiting to the survival of pada seedlings, and (b) how pada affects rice yield. Both of these are currently under investigation.

Table 6. The yield of upland rice in seven and four years rotation, in areas following pada at low and high densities during the fallow period, in a rotational shifting cultivation system in northern Thailand.

Pada density	Dense	Sparse	Dense	Rotation effect
Rotation	7 years	7 years	4 years	
	Yield (Mg ha^{-1})			
Grain	2.57[a]	0.83[b]	0.74[b]	$p < 0.01$
Straw	2.35[a]	0.97[b]	0.72[c]	$p < 0.01$
Total	4.92[a]	1.79[b]	1.47[c]	$p < 0.01$
Harvest Index	52.3	46.1	50.7	

a) Numbers in same row followed by different letters are significantly different by LSD ($p < 0.05$).

Table 7. Range and variation of rice yield in seven year rotation, in areas following pada at low and high densities during the fallow period, in a system of rotational shifting cultivation in northern Thailand.

Yield	Grain		Straw	
Pada density	Dense	Sparse	Dense	Sparse
	Mg ha^{-1}			
Maximum	4.53	1.56	3.80	1.75
Minimum	2.48	0.71	2.21	0.86
Mean (of 8 fields, 6 farms)	3.04	1.15	2.74	1.19
Standard deviation	0.71	0.33	0.59	0.30

Table 8. Yield components of upland rice in a rotational shifting cultivation system in northern Thailand with dense and sparse pada densities during the fallow period.

Yield component	Pada density		Significant Difference[a]
	Dense	Sparse	
Hills m^{-2}	6.2	5.5	**
Tillers hill^{-1}	13.9	10.3	*
Panicles hill^{-1}	12.3	7.1	**
Panicles m^{-2}	76.7	39.0	**
Fertile panicles (%)	90.1	66.6	**
1000 seed weight (g)	29.1	29.1	NS

a) NS = not significant ($p < 0.05$); ** = significant ($p < 0.01$)

Table 9. Nutrient concentration and contents at maturity of the rice after fallow with dense and sparse pada in a rotational shifting cultivation system in northern Thailand.

	Grain[a]		Straw[a]	
Pada density	Dense	Sparse	Dense	Sparse
(a) Nutrient concentration (%)				
N	1.13[a]	1.42[b]	0.48	0.63
P	0.23[a]	0.31[b]	0.04[a]	0.10[b]
K	0.42	0.45	2.47[b]	1.91[a]
Ca	0.11	0.10	0.33	0.36
Mg	0.11[a]	0.13[b]	0.13	0.13
(b) Nutrient content (kg/ha)				
N	34.1[b]	13.9[a]	13.6[b]	7.3[a]
P	7.6[b]	3.3[a]	2.1[b]	1.0[a]
K	13.1[b]	5.4[a]	62.9[b]	16.1[a]
Ca	3.1[b]	1.1[a]	8.1[b]	3.5[a]
Mg	3.4[b]	1.4[a]	3.3[b]	1.5[a]

a) Different letters designate significant difference (by LSD, $p < 0.05$) between dense and sparse pada patches for grain or straw yield.

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References

Kaya B. and Nair P.K.R. 2001. Soil fertility and crop yields under improved-fallow systems in southern Mali. Agrof Syst 52: 1–11.

Kwesiga F. and Coe R. 1994. The effect of short rotation *Sesbania sesban* planted fallows on maize yield. For Ecol Mgt 64: 199–208.

Kunstadter P. 1978. Subsistence agricultural economics of Lua' and Karen Hill Farmers, Mae Sariang District, Northwestern Thailand. In: Kunstadter P., Chapman E.C. and Sabhasri S. (eds), Farmers in the Forest. The University Press of Hawaii, Honolulu, pp. 71–133.

Mafongoya P.L. and Nair P.K.R. 1997. Multipurpose tree prunings as a source of nitrogen to maize under semiarid conditions in Zimbabwe. Part 1. Nitrogen-recovery rates as influenced by pruning quality and methods of application. Agrof Syst 35: 31–46.

Nye P.H. and Greenland D.J. 1964. Changes in the soil after clearing a tropical forest. Plant Soil 21: 101–112.

Rerkasem K. and Rerkasem B. 1995. Montane mainland South-east Asia: agroecosystems in transition. Global Environmental Change 5: 313–322.

Reuter D.J., Edwards D.G. and Wilhelm N.S. 1997. Temperate and tropical crops. Plant Analysis. an Interpretation Mannual. : 81–285.

Sanchez P.A. 1976. Properties and Management of Soils in the Tropics. John Wiley & Sons New York, New York, 618 pp.

Sabhasri S. 1978. Effects of forest fallow cultivation on forest production and soil. In: Kunstadter P., Chapman E.C. and Sabhasri S. (eds), Farmers in the Forest. The University Press of Hawaii, Honolulu, pp. 160–184.

Tarawali G. 1991. Effect of Stylosanthes fodder banks on grain yield of maize. Trop Grass 25: 26–31.

Wanatabe F.S. and Olsen S.R. 1962. Colorimetric determination of phosphorus in water extracts of soil. Soil Sci 93: 183–188.

Whitmore T.C. 1982. On pattern and process in forests. In: Newman E.I. (ed.), The Plant Community as Working Mechanism: Special Publication of the British Ecological Society Produced as a Tribute to A.S. Watt. Blackwell Scientific Publication, Oxford, pp. 45–59.

Youpensook S., Lumyong S., Yimyam N. and Dell B. Biodiversity of Arbuscular mycorrhizal fungi from rhizosphere of *Macaranga denticulata* (Euphorbiaceae) on the highland rotational shifting cultivation area in Thailand. Aust. J. Botany (in press).

Zinke P., Sabhasri S. and Kunstadter P. 1978. Soil fertility aspects of the Lua forest fallow system of shifting cultivation. In: Kunstadter P., Chapman E.C. and Sabhasri S. (eds), Farmers in the Forest. University Press of Hawaii, Honolulu, pp. 134–159.