CONSERVATION FARMING SYSTEMS IN TAWLD PROJECT

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INTRODUCTION

The Project has as its objective the development and stabilisation of areas of rainfed agriculture. These areas on the low and middle terraces of Northern Thailand are currently cropped either intensively or in an irregular but unstable system of 'slash and burn' or 'swidden' agriculture.

The current programme was prescribed by the World Bank to include a land development component involving the clearing by heavy equipment of natural vegetation which consists mainly of Dipterocarp-bamboo secondary regrowth. Stumps and roots are removed and soil conservation structures installed (contour banks and gully control structures). This is supported by a cropping systems and soil conservation research component aimed at developing farming practices which are acceptable, practical, and stable. A seed multiplication programme aims to provide quality cover crop seed which is generally otherwise unavailable. A seed multiplication programme aims to provide quality cover crop aeed which is generally otherwise unavailable. A land management advisory programme is extending the results of research

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through relevant agencies to the farmer level. It also distributes seed and assists in coordinating farmer involvement in the development work. Whole farm, and land use - yield, surveys are conducted annually to monitor changes in the project areas following development.

The early agricultural research was primarily of an agronomic nature. It covered aspects of crop improvement, plant protection and soil fertility. This was associated with some research on cropping systems, in particular the possibility of rice based double cropping.

In the current phase of the Project the research programme has been redirected to the development of conservation farming systems. This includes an emphasis of the problem of soil degradation and the introduction of soil erosion research.

Development of Conservation Farming Systems

Conservation farming systems are defined as practices suitable to the current socio-economic and technical conditions that will enable the long-term productivity of crop land by ensuring that appropriate soil chemical and physical conditions are maintained and that soil erosion is controlled. As such they are an integration of the following aspects of land use and crop management into a practical management package:

crop types and varieties
fertiliser requirements
pest and disease management
weed control
planting times and methods
crop rotations
tillage practices
residue management
runoff/soil water management
soil loss control

maintenance of suitable soil physical conditions
marketability of produce
social acceptability of practices
timetalbe of labour availability
risk and uncertainty (physical and economic)
profitability

There are aspects about which the Project already has considerable knowledge from previous research. The middle of the list contains aspects that are the subjects of present research to enable the formulation of detailed recommendations. The latter part of the list includes the socio-economic aspects. Information relevant to these is being sought and developed by the Socio-Economic Section of the Project.

From these research programmes it is possible to indicate the following as being necessary in the development of conservation farming systems for upland cropping:

* Cropping patterns should be on a rotation basis with cereals and legumes;
* adequate ground cover should be maintained at all times during the wet season to inhibit the breakdown of soil surface structure and hence surface sealing and erosion;
* cultivation with disc and rotary tillage impliments should be minimised to reduce the destruction of soil aggregation in the silty loam soils of Project areas;
* no-tillage should be used for sowing second crops in double cropping systems;
* plant spacings should have regard for weed control, soil erosion control, and yield;
* weed, pest, and disease control are essential management practices for economic returns;

* pre-emergent herbicides should be used for first crops sown with tillage;
* contour cultivation and contour row planting are essential for soil conservation;
* fertiliser should be used for peanuts and corn for maximum productions;
* no-tillage and mulching can be used to improve soil moisture status and therefore lengthen effective growing periods;
* legume cover crops should be sown following or just before the harvest of cereal crops wherever possible.

The cropping systems programe of the Project has had as its prime objective the development of economically and ecologicaly viable cropping systems for the uplands of Northern Thailand. Reduction of soil erosion, weed control, and nitrogen and organic matter accretion are seen as the major ecological aims. Improvement of farmers incomes, in both the short and long-term, is the only realistic incentive for the adoption of these ecological desirable cropping systems.

Substantial progress toward this objective has been made over the past few years. Reference is made to the work of IITA, NCSU, ICRISAT, and other agencies on which the Project programme was based. The cropping systems described are based on the components:

1) Upland rice mono-crop with reduced tillage.
2) Corn/cowpea relay-crop with no-tillage.
3) Peanut/pigeon pea relay-crop with disc tillage.
4) Corn with stylo live mulch no-tillage.

BACKGROUND

Cropping systems work commenced at the begining of the TALD Project with rotation and fertiliser experiments at Sa (NLDC) and at Hang Chat (LLDC). These used rotation of peanut and rice with application of superphosphate, ammonium sulphate, lime, and molybdenum. After ten years it became obvious that this simple rotation of peanut with upland rice was not preventing the decline in crop production. Eventually more intensive green manure applications were tried. Very substantial increases of yield of upland rice were obtained in response to applications of soybean trash as mulch or incorporated as green manure (Hoult 1978).

There was a significant response of upland rice to soybean trash regardless of whether it was incorporated or mulched. There was no significant response to applications of ammonium sulphate which nevertheless **appeared** to decrease yield on the plots which did not have any residue. This was taken to indicate that the primary effect of mulch and/or green manure lay in improved soil moisture conditions rather than in increased nitrogen supply. Emergence and establishment were much better on mulched plots but incorporated plots recovered at the tillering stage and yielded well.

Table 1

EFFECT OF SOYBEAN RESIDUES AND NITROGEN ON YIELD OF UPLAND RICE

SOYBEAN TRASH TREATMENT

T_1 NIL

T_2 2 tonnes per rai incorporated

T_3 2 tonnes per rai mulched

NITROGEN TREATMENT

N_1 0 kg ammonium sulphate per rai

N_2 15 kg

N_3 30 kg

MEAN YIELD OR UPLAND RICE KG PER RAI

	N_1	N_2	N_3	X	
T_1	353	285	315	318	b
T_2	562	676	505	581	a
T_3	563	472	629	555	a
X	493	478	483		
	a	a	a	DMRT 5%	

Following this a range of green manure crops were grown for one wet season and followed in the next with upland rice (Pintarak et al 1982). The upland rice was sown into ploughed soil after residues of the previous years green manure crop had been incorporated by rotary hoe. Grain from the green manure crops was harvested and removed (see Table 2).

Table 2

YIELD OF GRAIN AND STOVER AND BENEFIT TO A FOLLOWING RICE CROP OF NINE GREEN MANURE CROPS

GREEN MANURE	GREEN MANURE kg/rai			FOLLOWING RICE kg/rai	
	Grain	Stover	HI%		
Dolichos lab lab	520	2045	20	337	a
Cowpea (blackbean)	246	1970	11	363	a
Centrosema		1390		293	ab
Peanut	440	648	40	275	abc
Cowpea (redbean)	349	420	45	272	abc
Crotolaria juncea		1201		268	abc
Mungbean (M58)	271	200	58	234	bc
Soybean (SJ4)	349	357	49	230	bc
Pigeon Pea (local)	82	2980	3	202	bc
Upland Rice Control	203	572	26	177	c

DMRT 5%

Blackbean and lab lab, legumes of low harvest index, were superior in their effect on a following rice crop. The higher harvest index grain legumes redbean, peanut, mungbean, soybean gave lower rice yields in the following year. Pigeon pea was anomalous in that it produced the highest yield of stover with the lowest harvest index but its effect on the following rice was comparable with mung or soy and not significantly better than rice. This is not consistent with the hypothesis that the benefit of green manure are primarily associated with soil moisture and the reasons for this are not clear. Immobilisation of nitrogen and allelopathic effects may be involved. Centrosema and Crotolaria returned substantial quantities of dry matter and improved rice yields.

Further work (Pintarak et al 1983) concentrated on grain legumes which had established markets and which allowed for double cropping. Thus seven cropping systems were tested at LLDC and NLDC. Yields of grain legumes and of following rice are tabulated below (Tables 3, 4 and 5).

A number of observations may be made from these data. Blackbean gave the most consistent yield increase of rice in the following year but the multiple cropping systems using more than one legume showed promise as well. At NLDC the second crop sequential legumes did not yield well due to poor rainfall. Unfortunately, these trials do not have a monocrop rice control for comparison but the rotation rice yield are generally high enough to be encouraging.

Table 3

CROPPING SYSTEM AND YIELD LLDC

CROP		YIELD (kg/rai)			
2524	2525	2524		2525	
		1st	2nd		
Rice (R258), Mungbean (M77)	Rice	383	67	193	c
Rice (258), Redbean	Rice	408	92	192	c
Peanut(T9), Mungbean (M77)	rice	441	128	269	b
Peanut(T9), Redbean	Rice	435	193	271	b
Corn(SI)/Mungbean (M77) inter, Mungbean (M77)	Rice	57/220	73	202	c
Corn (SI)/Mungbean (M77) inter, redbean	Rice	153/239	256	273	b
Blackbean	Rice	321		342	a

Rice 2524 R258, maturity approximately 110 days
Rice 2525 Siew Mae Chan, photosensitive maturity mid October

Table 4
CROPPING SYSTEM AND YIELD NLDC WITHOUT SUPERPHOSPHATE

CROP		YIELD (kg/rai)		
2524	2525	2524		2525
		1st	2nd	
Rice (R258),Mungbean (M77)	Rice	184	10	168 b
Rice (258),Redbean[1]	Rice	154	16	201 b
Peanut (T9),Mungbean[2] (M77)	Rice	324	49	368 a
Peanut (T9),Redbean	Rice	307	91	416 a
Corn (S1)/Mungbean (M77) inter, Mungbean (M77)	Rice	250/95	43	427 a
Corn (S1)/Mungbean (M77) inter, Redbean	Rice	250/99	103	399 a
Blackbean	Rice	193		417 a

Rice 2524 R258, maturity approximately 110 days
Rice 2525 Siew Mae Chan, photosensitive maturity mid October

Table 5
CROPPING SYSTEM AND YIELD NLDC SUPERPHOSPHATE 20 kg/rai

CROP		YIELD (kg/rai)		
2524	2525	2524		2525
		1st	2nd	
Rice (R258),Mungbean (M77)	Rice	171	21	263 b
Rice (258),Redbean	Rice	136	56	199 b
Peanut (T9),Mungbean (M77)	Rice	238	65	307 a
Peanut (T9),Redbean	Rice	263	131	344 a
Corn (S1)/Mungbean (M77) inter, Mungbean (M77)	Rice	449/99	55	383 a
Corn (S1)/Mungbean (M77) inter, Redbean	Rice	465/114	103	352 a
Blackbean	Rice	145		322 a

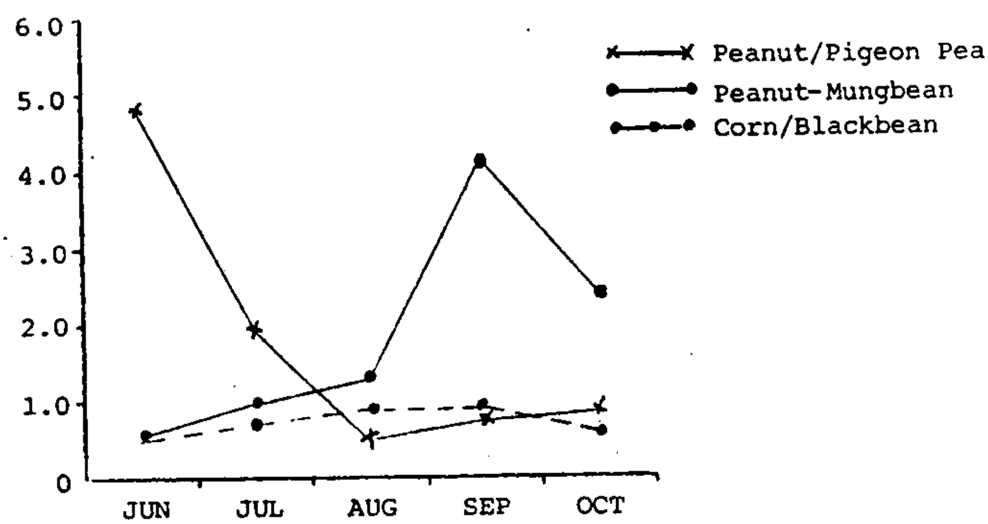
Rice 2524 R258, maturity approximately 110 days
Rice 2525 Siew Mae Chan, photosensitive maturity mid October

At LLDC, peanut followed by mungbean or redbean and corn followed by redbean gave yields of rice approximately 80% of those following blackbean. These cropping systems, particularly peanut-mungbean sequential, may be more economicaly attractive than blackgean and the system peanut-mungbean followed by rice promises the highest gross returns of the systems tested here. Results at NLDC were consistent with those from LLDC but the corn/mungbean and corn/redbean systems were more successful. There was a response of corn to superphosphate and this appeared to be a response to S rather than P, consistent with the work of Indarapun et al (1983). Application of ammonium sulphate to corn as recommended by Normal (1984) would improve the economics of corn based cropping systems.

While these cropping systems are promising there are a number of factors which limit their usefullness and so refinements were necessary.

Peanut-mungbean sequential presents management problems and unacceptability high erosion risk. Peanut is harvested mid to late August with substantial soil disturbance. In notrhern Thailand late August rainfall is highly erosive and harvesting produces unacceptably high soil loss. Figure 1 illustrates the increase in soil loss following harvest of peanut crop and during sowing and establishment of the mungbean crops compared with rice. There are slight increases in the distributions of soil loss for corn/blackgean and peanut/pigeon relays but they are not as great as the increase for the peanut mungbean sequential.

Figure 1
DISTRIBUTION OF RATIOS OF SOIL LOSS FROM PEANUT-MUNGBEAN SEQUENTIAL, PEANUT/PIGEON PEA RELAY AND CORN/BLACKBEAN RELAY TO SOIL LOSS FROM RICE. DATA FROM TRIALS AT HANG CHAT, LLDC.



If cultivation is needed to control weeds and plant a second crop this erosion hazard is increased (Figure 1). Grass weeds, particularly Digitaria adscendes flourish after a peanut crop and weed control is difficult. The use of an effective knockdown herbicide, such as Roundup, is expensive and the second crop may be not recover this input. By peanut harvest D.adscendens has set a large amount of seed and a later weeding is usually needed. Cultivation to control weeds is difficult and often not possible due to wet conditions mid-late August. Any delay in planting the second crop leads to a high risk of failure due to dry conditions in October. A drought resistant relay crop which is planted well before peanut harvest has obvious advantages in both crop production and soil conservation (Figure 1). Pigeon pea has been grown in this way at ICRISAT and based on this, work on peanut/ pigeon pea relay cropping was commenced at LLDC.

Second cropping after corn presents less problems of weeds and, if sown without tillage, virtually no erosion hazard. While sequential cropping is possible, relay intercropping maximises use of available moisture and light and minimises weed and soil erosion problems. Relay cropping of corn with blackbean or mungbean are being tested under the Project research program.

THE CORN/BLACKBEAN RELAY CROPPING SYSTEM

Blackbean is photo-period sensitive and flowers late October in northen Thailand. Trials have shown that it may be sown as late as mid August without serious loss of yield. Corn is sown on 0.75 x 0.25m spacing late May. Blackbean is intersown as a relay crop on 0.75 x 0.25m spacing without tillage 60-70 days later. The influence of planting date is illustrated in the Table 6.

Table 6

INFLUENCE OF BLACKBEAN PLANTING DATE ON YIELD OF BLACKBEAN AND OF A FOLLOWING UPLAND RICE CROP PLANTED WITHOUT TILLAGE

TIME OF PLANTING BLACKBEAN	YIELD OF BLACKBEAN Blackbean kg/rai		YIELD OF BLACKBEAN Stover kg /rai	YIELD OF RICE 2526 kg/rai (14%) N_0	YIELD OF RICE 2526 kg/rai (14%) N_3	YIELD OF RICE 2526 kg/rai (14%) Mean
22/6	132	bc	430	222	225	224
7/7	140	bc	1000	204	213	208
22/7	175	abc	760	164	235	199
6/8	135	bc	640	228	203	216
23/8	185	a	480	194	196	195
7/9	110	c	290	191	225	208
22/9	10	d	30	64	91	77
7/10	29	d	40	146	98	121
	DMRT 5%				LSD 5% = 64	
			Mean 177	186		
				LSD 5% = 21		

Yield of blackbean was not significantly reduced by sowing as late as the end of August. The 23/8 planting was favoured by very wet conditions while rainfall in June and July was inadequate and establishment of earlier plantings was not ideal. It appears that blackbean is best planted in August or late July which makes it well suited as a relay cover crop sown into corn at approximately 60-70 days.

Yield of rice, planted without tillage into trash of the previous years blackbean, was reduced significantly where the trash was less than approximately 300 kg/rai. There was no significant response to 3 kg N/rai applied as ammonium sulphate at maxiumum tillering.

Blackbean sown into corn at 60 DAS has established well and given acceptable yields of 150-200 kg/rai at both NLDC and LLDC. A number of varieties of cowpea are being tested at LLDC for suitability in this cropping system. They include varieties selected for short growing season and high yield as well as lower harvest index varieties used as post corn cover crops. Mungbean is also being tested. Blackbean is clearly superior as a cover crop and is favoured.

THE PEANUT/PIGEON PEA RELAY CROPPING SYSTEM

Peanut is an important cash crop in the uplands of northern Thailand. A second crop of mungbean or cowpea may be planted after peanut but, as outlined above, this presents problems of weed control, land preparation, and soil erosion. A relay crop of pigeon pea, sown into the peanut crop at 10-20 DAS, has shown promise as a post peanut cover/cash crop. Pigeon pea produces good yields of grain 100-200 kg/rai) or of forage as well as providing ground cover, weed smother, and mulch for the following seasons crop.

Two tall varieties of pigeon pea (ICP 7035 and UQ 34) reduced yields of intercropped mungbean and peanut in a trial at LLDC. A dwarf cultivar (UQ 4738) did not significantly reduce intercrop yields. The following year, pigeon pea sown into peanut at 20 DAS had difficulty competing with the peanut and this system needs further refinement in terms of planting times and spacings.

The three varieties of pigeon pea were planted in separate trials with five cropping systems VIZ:

1) Peanut monocrop
2) Mungbean monocrop
3) Peanut/pigeon pea intercrop
4) Mungbean/pigeon pea intercrop
5) Pigeon pea monocrop

Spacings used were:	Peanut	0.30 x 0.30 m
	Mungbean	0.30 z 0.15 m
	Pigeon pea	1.50 x 0.25 m

The results are shown in Table 7.

Table 7

MUNGBEAN AND PEANUT MONOCROP COMPARED WITH INTERCROP WITH PIGEON PEA

PIGEON PEA VARIETY	YIELD OF MUNGBEAN kg/rai (14%) MONOCROP	INTERCROP	LSD 5%
ICP 7035	189	121	18
UQ 34	137	76	49
UQ 4738	195	178	95
	YIELD OF PEANUT kg/rai (14%)		
ICP 7035	331	146	52
UQ 34	343	206	41
UQ 4738	311	255	98

Rainfall distributions in northern Thailand are such that planting later than mid June carries an unacceptable risk of crop failure due to dry conditions in July. Planting earlier than mid May is usually not possible and so a delay between planting the main cash crop (peanut or mungbean) and the cover/cash crop (pigeon pea) of approximately 10-20 days appears to be optimal. Thus peanut or mungbean may be planted mid to late May and pigeon pea intersown early to mid June.

Dwarf pigeon pea may be planted on 1.5m row spacing but the taller cultivars appear to be better planted at a wider spacing of approximately 2m. Giant pigeon pea provides better soil cover, higher organic matter production, and better drought resistance than do dwarf cultivars.

Benefits of Pigeon Pea Mulch to No-Till Corn

Five pigeon pea based cropping systems were tested and the following year the plots were sown to corn without tillage.

The five cropping systems were :

1) Peanut monocrop (P)
2) Mungbean monocrop (M)
3) Peanut-Pigeon pea intercrop (P/PP)
4) Mungbean-Pigeon pea intercrop (M/PP)
5) Pigeon pea monocrop (PP)

Perennial pigeon pea (cv ICP 7035) was sown May 2528 on 1.5 x 0.25m spacing with or without inter-row peanut and mungbean ICP 7035 is a tall cultivar of pigeon pea and it reduced yields of intersown peanut and mungbean and produced a close canopy (see above). At the break of the wet season (10 May) corn (cv Suwan 1) was sown no-till under the pigeon pea canopy at 0.75 x 0.25m spacing (8500/rai) and then the pigeon pea slashed and left on the plots. Roundup (300 ml/rai) was applied after slashing pigeon pea and before corn emergence. Initial weed kill was good.

Emergence of corn under pigeon pea trash was markedly better than under weed mulch on the no-pigeon pea plots. Weed numbers were higher following peanut or mungbean than following pigeon pea (Table 8).

Table 8
CORN ESTABLISHMENT AND WEED POPULATION UNDER PIGEON PEA BASED CROPPING SYSTEMS

Cropping Systems		Corn Establishment /rai	Weed Numbers Narrow Leaf	($x10^3$/rai) Broad Leaf
1	P	7000	309	93
2	M	5000	970	10
3	P/PP	9000	160	12
4	M/PP	3300	94	34
5	PP	7100	83	10
LSD	5%	1600	245	38
	1%	2100	337	52

Fertiliser treatments were applied to split plots. Six rates of N (0,2,4,8,16,32 kg N/rai) and two of S (0,4 kg S/rai) were applied in factorial combination with 1/3 N at sowing and 2/3 N at 30 DAS. S was applied at sowing. All fertilisers were incorporated as sidebands.

Yield of corn was higher from pigeon pea plots but there was no cropping systems x fertiliser interaction indicating that the difference was due to physical factors i.e., improved emergence and better moisture conditions under pigeon pea trash. There was a response to nitrogen but no response to sulphur.

TABLE 9

YIELD OF CORN SOWN WITHOUT TILLAGE INTO TRASH FROM PIGEON PEA BASED CROPPING SYSTEMS

Cropping System	Yield of Corn kg/rai (15%)	g/cob
Peanut monocrop	304	58
Mungbean monocrop	288	64
Peanut/Pigeon Pea intercrop	486	77
Mungbean/Pigeon Pea intercrop	485	84
Pigeon Pea monocrop	421	77
LSD 5%	120	24

Table 10

RESPONSE IN YIELD OF CORN TO N AND S FERTILISERS

Yield of Corn (kg/rai) (14%)

	S_0	S_4	Mean
N_0	328	349	338
N_2	373	412	392
N_4	366	388	377
N_8	398	409	404
N_{16}	391	446	418
N_{32}	436	464	450
Mean	382	411	

LSD 5%	S effect	38
	N effect	66
	S x N	94

LIVE MULCH CROPPING SYSTEMS

Centrosema and stylo grown as ley cover crops have been shown to increase yields of following cereal crops (Pintarak et al, 1982, Jones et al 1983). Agboola and Fayemi (1971, 1972) found that when corn was intercropped with calopo or cowpea corn yields were maintained over a period of four years. Mucuna utilis and Phaseolus lunatus competed with corn while calopo and cowpea did not.

Incropping systems trials at LLDC stylo guyanensis (cv Cook), stylo hamata (cv Verano), centro pubescens, and siratro have been observed to re-establish strongly after a crop of corn and rather less strongly, but adequately, after a crop of upland rice. In order to evaluate the benefit of these cover crops to following rice or corn crops, areas were sown at LLDC mid wet season and corn and rice planted into them without tillage at the beginning of the following wet season. Roundup was used to knockdown the cover crops, and rice and corn dibble sown through the mulch. Corn was sown at 5.3 plants per square meter (0.75 x 0.25m thinned to one plant per hill) and rice at approximately 100 plants per square meter (0.30 x 0.15m with 5 seeds per hill).

Establishment of both rice and corn were satisfactory and the early knockdown of covers was effective. As the rice matured siratro and alysicarpus appeared to compete to the detriment of the rice. These, together with verano and cook, established well post harvest to give cover similar to that achieved the previous year. Stylo, which did not appear to compete with rice, is favoured as a low-cost, self sustaining, post-harvest cover crop.

Ammonium sulphate was applied to split plots on both rice and corn. To rice 3 kg N per rai was applied at maximum tillering and to corn 8 kg N at 35 DAS.

The Effect of Cover Crops on Rice Yields

Yield of rice sown without tillage into the trash of a previous years cover crop was highest following blackbean. There was no significant difference between the effects of dolichos lablab, stylo, centro, and alysicarpus. Siratro competed with rice and significantly reduced rice yield. There was no significant response to nitrogen.

Table 11 shows the effect of the cover crop on rice yields.

Table 11

EFFECT OF COVER CROPS ON YIELD OF RICE SOWN WITHOUT TILLAGE

PREVIOUS YEARS COVER CROP	YIELD OF RICE kg/rai (14%) -N	+N	MEAN
Alysicarpus	207	210	208
Blackbean	299	269	274
Stylo Verano	208	228	218
Stylo Cook	212	202	207
Centrosema	204	208	206
Siratro	118	156	137
Lab Lab (Dolichos)	179	179	179
		LSD 5%	49
MEAN	204	208	
	LSD 5%	26	

The Effect of Cover Crops on Corn Yields

Table 12 show the effect of cover crop on corn yields.

Corn following blackbean gave the highest yield, but the difference was not significant. There was a significant response to ammonium sulphate (40 kg/rai applied at 35 DAS). Verano appeared to depress corn yield while Cook did not. The reasons for this are not clear.

Cook, verano, centro, and siratro re-established strongly after corn and gave good soil cover at the end of the following dry season. Re-establishment following rice was not as good.

Table 12
EFFECT OF COVER CROPS ON YIELD OF CORN SOWN WITHOUT TILLAGE

PREVIOUS YEARS COVER CROP	YIELD OF CORN kg/rai (14%) N_0	N_8	MEAN
Alysicarpus	396	605	500
Blackbean	542	848	695
Stylo Verano	319	489	404
Stylo Cook	465	706	586
Centrosema	510	685	598
Siratro	359	647	503
Lab Lab (Dolichos)	375	764	570
	LSD	5%	273
MEAN	424	678	
	LSD 5%	91	

6.6 DISCUSSION

The importance of returning organic matter and of maintaining soil cover by crop canopy and mulch are well accepted in long-term cropping of ultisols and oxisols in the semi-arid tropics (Sanchez and Selinas 1981, Lal & Kang 1982). In northern Thailand these soils tend to be cropped by farmers with limited or no tenure. Conservation farming is a long-term strategy and the factor of land tenure is basic to farmers adopting a responsible attitude to their land.

Management of the uplands of northern Thailand is largely exploitive. Cultivation is usually by disc plough using contractors. Weed control is usually less than ideal by one or more hand weedings and levels of production are generally low. Double cropping and rotation of legumes with cereals are practised by few farmers with the majority taking one crop, usually peanut or upland rice, with minimum inputs. On adjacent lowlands farmers use more intensive methods and obtain correspondingly better yields.

It is clear that the major limitation to production on these soils is poor management. It is also clear that farmers are capable of better managing their land. In order to develop conservation farming systems that will be viable in the long-term it is necessary to find not only technical solutions but solutions that will provide sufficient profit to encourage farmers to use them.

The results from a 2 year project cropping systems demonstration on farmers land indicate that such solutions are feasible (R.J. Trethewie 1985). The use of peanut-mungbean sequential rotated annually with rice increased rice yields by 50% overall and in individual cases by more than 100% on farmers land (Table 13).

Table 13
NADP SUB-PROJECT A 2 YEAR CROPPING SYSTEMS DEMONSTRATIONS
PRODUCTION RESULTS 1984 - kg/rai

CROP	1983 SEASON	RICE	PEANUT/MUNG
SOWN	1983 SEASON	RICE	RICE
Ref.No.	Location		
50	Phrae/Song	280	243
51	Phrae/Song	173	253
52	Phrae/Song	200	293
53	Phrae/Song	200	300
54	Phrae/Song	250	300
56	Phrae/Song	250	300
58	Phrae/Song	267	413
59	Phrae/Song	267	400
60	Phrae/Song	322	427
62	Phrae/Song	267	280
67	Nan/Muang	260	380
68	Nan/Muang	300	650
70	ChiangRai/WiangPaPao	220	350
71	ChiangRai/WiangPaPao	270	430
72	ChiangRai/WiangPaPao	210	410
73	ChiangRai/WiangPaPao	140	290
74	ChiangRai/WiangPaPao	220	400
75	ChaingRai/WiangPapao	45	190
76	ChiangRai/WiangPaPao	110	154
77	ChiangRai/Muang	370	220
80	ChiangRai/Mae Suai	63	105
81	ChiangRai/Mae Suai	115	220
82	ChiangRai/Mae Suai	89	185
83	ChiangRai/Mae Suai	146	207
	$\bar{X}$	209.7	308.3

Figure 2
THE EFFECT OF CROP MANAGEMENT ON SOIL EROSION AND RUNOFF FOR UPLAND RICE AND PEANUT

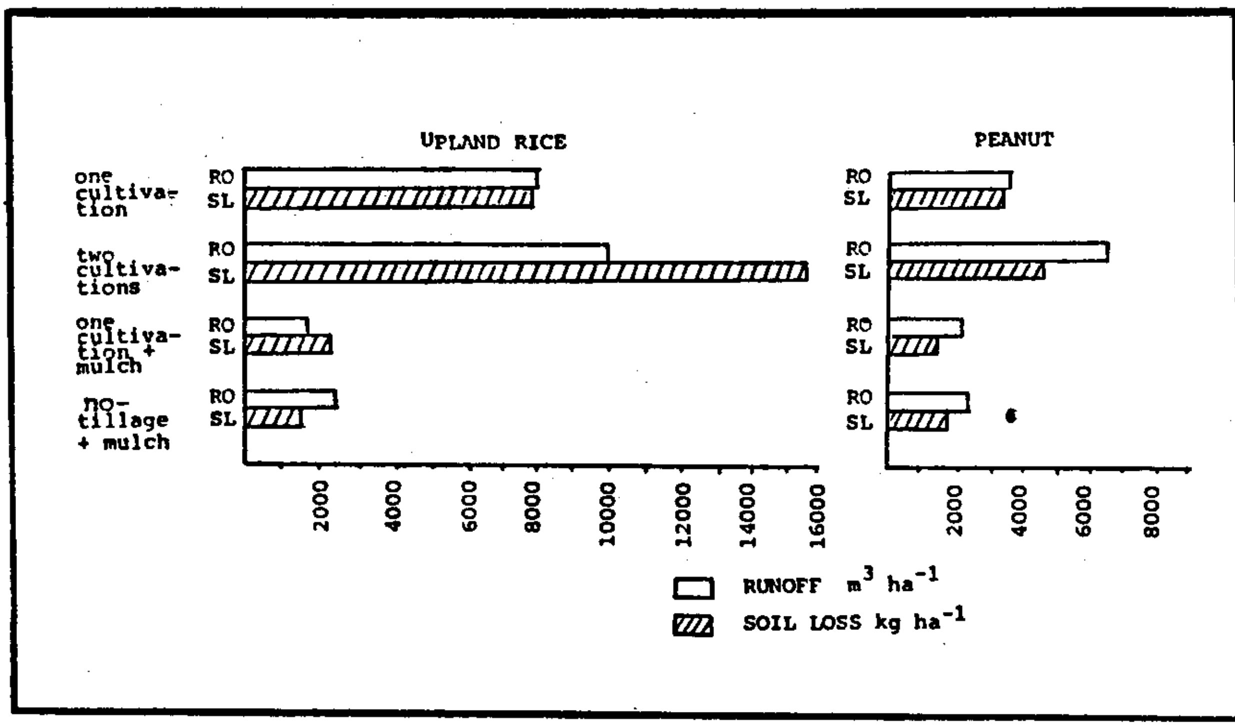


Table 14
AVERAGE RICE AND PEANUT YIELDS FROM DIFFERENT CROP MANAGEMENTS

TREATMENT	RICE YIELD ($t\ ha^{-1}$)	PEANUT YIELD ($t\ ha^{-1}$)
1 cultivation	0.9	1.5
2 cultivations	0.4	1.3
1. cultivation + mulch	1.6	2.0
no-tillage + mulch	0.8	1.4

Disc cultivation with pre-emergence herbicide gives good establishment and weed control but leads to soil structure breakdown and unacceptable levels of soil erosion. The one and two cultivation treatments in Figure 2 are examples of the high soil losses that can occur under this management.

Mulching reduces runoff and soil loss from disced plots to similar levels as no-tillage (Figure 2). Unlike no-tillage, disc, cultivation plus mulch improves yields (Table 14). Where residues are incorporated it will probably be necessary to apply mulch to protect surface soil structure and to improve rainfall acceptance.

The development of viable upland conservation farming systems in northern Thailand is likely to involve reduced tillage and increased organic matter inputs through rotations, cover crops, and mulch. Inorganic fertilisers will almost certainly be needed at some stage, particularly as production levels increase. At present corn is the only crop to give economic returns to fertiliser in Project areas. Gypsum and lime should be applied to peanut and rock phosphate may be needed to maintain long-term productivity in rotations. Potassium will probably not be needed for many years.

It may well emerge that a pasture ley is necessary to maintain the productivity of these soils.

APPROPRIATE SYSTEMS

Upland farmers in northern Thailand tend to grow corn on newly cleared land, reverting to upland rice as soil nitrogen reserves decline, and then to peanut in rotation with upland. rice. Mungbean is sometimes grown as a second crop following peanut. This farming system would probably be stable in the long-term on well structured soils with suitable additions of fertilisers, manures, and with return of crop residues. On less stable soils of low organic matter content, and without inputs of crop residues, fertilisers, and manures, nutrient levels decline and soil structure collapses. After years of cropping, surface crusting, decreased infiltration and consequent runoff and soil erosion, and weed build up present major limitations to crop production. Surface crusting and decreased infiltration increases the problem of dry periods which occur in most parts of northern Thailand in most years.

Conservation farming systems designed to maximise soil cover by canopy and by mulch have been developed in the Project research programe. The cover provided by one of these rotations is shown schematically in Figure 3. Canopy cover of peanut-pigeon pea and corn-blackbean at the end of the high erosive period and the stover mulch at the beginning of the following wet season reduce soil erosion. These rotations also aim to improve crop production through cereal-legume rotation and by decreased weed competition.

There is a need to develop conservation farming systems for a range of soil types with varying degrees of structural and nutritional degradation and under different climatic conditions as shown in Table 15.

On better soils in areas of more reliable rainfall corn based farming systems are favoured. The corn-blackbean system may prove to be stable on a continuous basis. At Farm Suwan corn yields have been maintained over several years by including lab lab or mimosa as post corn cover crops (Norman, pers comm.). In the Chiang Rai area on better soils the corn-mimosa system appears to be stable in the long-term. Corn-blackbean has the advantage of providing a second saleable crop. These findings are consitent with those of Agboola and Fayemi (1971,1972).

It may be desirable to rotate corn-blackbean with upland rice and this system is showing promise in recent work at NLDC. Rice yields following corn/blackbean are superior to continuous rice. On poorer soils, or soils which have long histories of cropping, the peanut pigeon pea system (rotation2 in Figure 3) is favoured. These soils need cultivating to obtain acceptable establishment and a pre-emergence herbicide is necessary to control weeds. The pigeon pea cover crop should provide the weed smother and mulch to allow a successful no-tillage crop of corn the following year. Blackbean sown into the corn should further provide cover and mulch for a following no-tillage upland rice crop. The upland rice component completes this rotation and peanut pigeon pea follows.

Table 15
TAWLD CONSERVATION CROPPING SYSTEMS RECOMMENDATIONS

Soil Fertility	GOOD		POOR		VERY POOR	
RAINFALL	RELIABLE	UNRELIABLE	RELIABLE	UNRELIABLE	RELIABLE	UNRELIABLE
CROPPING SYSTEM	CORN	PEANUT/PIGEON PEA		STYLO/CROP		STYLO
YEAR 1	CORN/ BLACK BEAN LAB LAB OR MIMOSA	PEANUT/PIGEON PEA		STYLO		STYLO
YEAR 2	UPLAND RICE	CORN/BLACK BEAN		CROP/STYLO		STYLO
YEAR 3	CORN/ BLACK BEAN	UPLAND RICE		CROP/STYLO		STYLO
YEAR 4	UPLAND RICE	PEANUT/PIGEON PEA		CROP/STYLO		STYLO

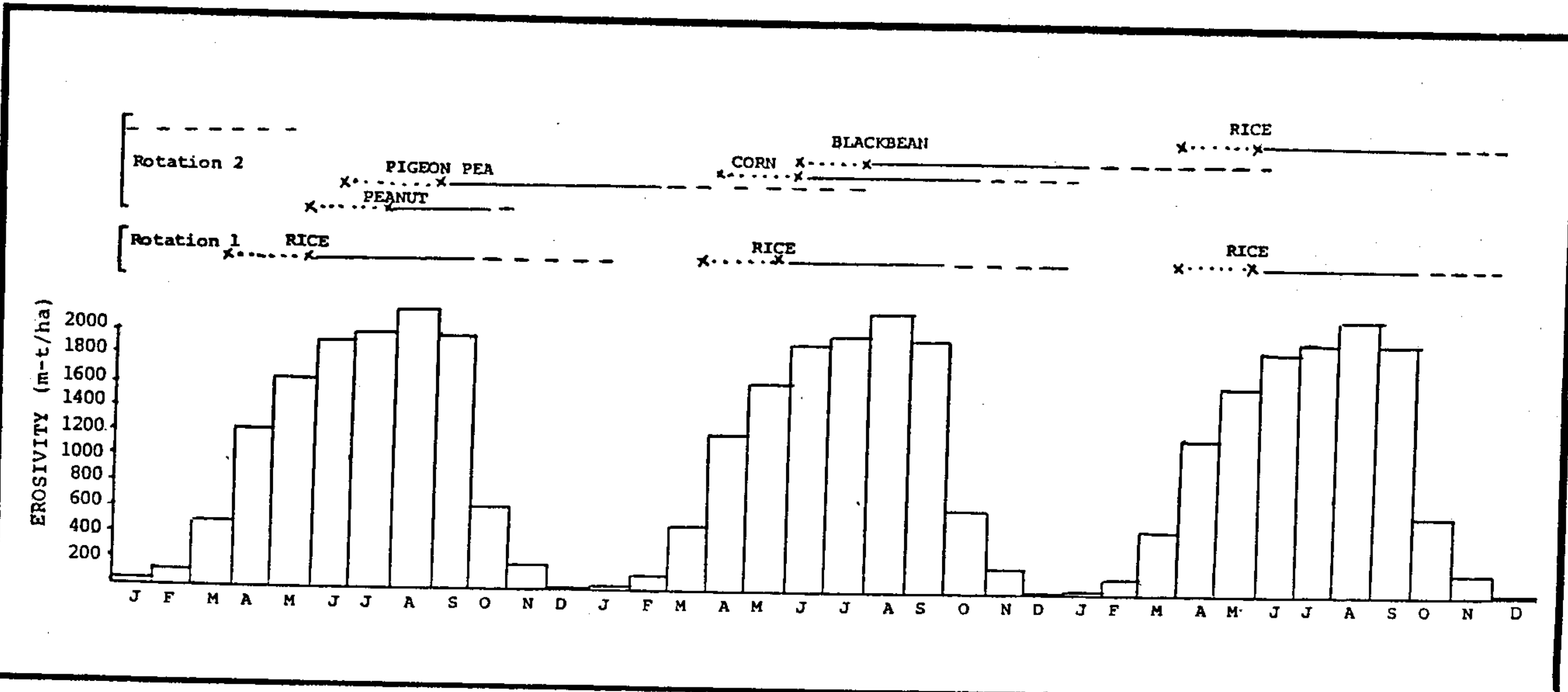
On poor soil or degraded land a stylo ley may be necessary with no-tillage cropping after one or two years. Depending on rainfall patterns corn, rice, kenaf, or cassava could be planted into the stylo after 2,4-D knockdown. If grasses are present with the stylo, roundup may be used with the 2,4-D. Depending on the extent of soil degradation a stylo ley may be needed in alternate years.

On better soils with more reliable rainfall, cropping each year may be possible with stylo re-establishing after harvest of the crop. In areas of unrelaiable rainfall the stylo ley combined with some form of animal production gives a measure of insurance against drought.

Alternation of rice and peanut in 10 cm strips on the countour has been shown to reduce soil loss at LLDC. Strip rotations of the cropping systems described here would further enhance the benefits in terms of soil conservation.

Figure 3

MONTHLY RAINFALL EROSIVITIVES FOR NAN AND THE PERIOD FOR THE CROP TO PRODUCE 3 TONNED DRY MATTER/HA (x...x) AND THAT THE GROUND SURFACE IS PROTECTED BY THE GROWING CROP (_____) AND BY CROP RESIDUE (------) FOR CONTINUOUS RICE (ROTATION 1) AND PEANUT/PIGEON PEA → CORN/BLACKBEAN → RICE (ROTATION 2)



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