5. Results and Discussion

5.1 The early rainy season peanut experiment

5.1.1 Kernel yield and yield component

The error variances of kernel yield in the alley and the non-alley plots were shown to be homogeneous. The combined analysis of variance indicated that yield variation between the alley and the non-alley was not significant.

Mulching with leucaena leaves had no significant effect on kernel yield. However, application of phosphate fertilizer at 56 kg P_2O_5/ha increased kernel yield from 430 kg/ha to 694 kg/ha (Table 3).

Table 3 Effect of phosphate fertilizer on peanut kernel yield (kg/ha)

Leucaena mulching	Phosphate fertilizer	
	0	56 kg/ha
Mulching	483	689
Non-mulching	377	699
Mean	430	694

LSD 0.05 152 kg/ha

The combined analysis also indicated that there was significant interaction between the site and phosphorus level on kernel yield as shown in Figure 2. The differential response to phosphate fertilizer was found to be higher in the non-alley plot (440 kg/ha) than in the alley plot (90 kg/ha).

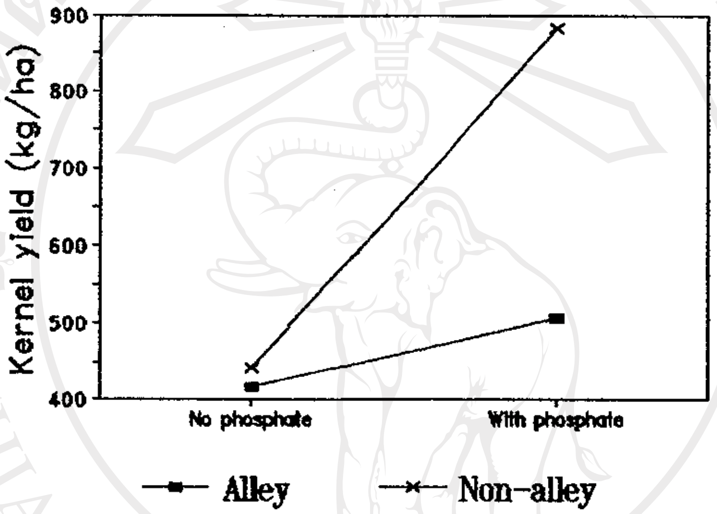

Figure 2 Peanut kernel yield in response to phosphate fertilizer in the alley and the non-alley plots.

The variations in peanut yield components and shelling percentage between the alley and the non-alley plots were found to be non-significant different. The mulching treatments also provided non-significantly effects on the characters mentioned above. The application of phosphate of fertilizer had increased number of pods/m^2 by 39 percent and number of seed/m^2 by 44 percent (Table 4).

Table 4 Peanut yield component and shelling percentage as affected by phosphate fertilizer

Phosphate treatment	100 seed (g)	No.of seed/m^2	No.of pod/m2	shelling (%)
Phosphate	31.10	218	128	68.8
No phosphate	27.60	151	92	67.2
CV(b)%	18.14	26.57	25.28	4.22
LSD 0.05	NS	46	26	NS

5.1.2 Dry matter yield and nutrient composition

Peanut dry matter yield between the alley and the non-alley plot had shown non-significant difference. The mulching treatment did not affect peanut dry matter yield Effect of phosphate fertilizer had increased peanut dry matter yield in every plant part (Table 5).

Plant analysis of peanut at harvest, showed that nitrogen, phosphorus and potassium content in every treatment were sufficient (Table 6). The phosphate fertilizer had increased the uptake of phosphorus, nitrogen and potassium in both mulching and non-mulching plot. However, pod yield was lower than 1000 kg. This lower yield was due to low plant density and wide plant spacing.

Table 5 Effect of phosphate fertilizer on peanut dry matter yield (kg/ha)

Leucaena mulching	Phosphate fertilizer 0			Phosphate fertilizer 56.25 kg/ha		
	shoot	shell	seed	shoot	shell	seed
Mulching	1845	214	483	2489	299	689
Non-mulching	1589	190	377	1880	291	699
Mean	1717	202	430	2185	295	694
				shoot	shell	seed
LSD 0.05				378	NS	152
CV(b) %				20.56	24.17	28.7

Table 6 Effect of phosphate fertilizer on peanut pod yield, nutrient content and nutrient uptake in the alley and the non-alley plots.

Treatment	Pod yield (kg/ha)	N		P		K	
		Content (%)	Uptake (kg/ha)	Content (%)	Uptake (kg/ha)	Content (%)	Uptake (kg/ha)
Mulching							
Phosphate	988	3.70	36.96	0.31	3.05	0.83	8.19
No phosphate	697	3.80	26.55	0.27	1.89	0.71	4.97
Non-mulching							
Phosphate	990	3.80	38.19	0.30	3.00	0.70	6.93
No phosphate	567	3.70	21.20	0.27	1.55	0.69	3.93
Nutrient composition in peanut pods (1)	1000	3-3.50	30-35	0.26	2.58	0.6-1	6-10

Note: (1) Bunting et al., 1985

5.1.3 Economic assessment of fertilizer effects on peanut crop

Economic assessment of phosphate fertilizer used in the alley and the non-alley plots were analyzed by using partial budgeting method. Applied phosphate produced higher yield of 694.23 kg/ha and higher revenue of 18,049.20 baht/ha with added revenue of 6,874.40 baht/ha but the total variable cost was increased to 1,233.89 baht/ha. However, application of phosphate fertilizer gave the marginal rate of return of 557.13 percent when compared with no application (Table 7). Therefore, application of phosphate fertilizer would be economically viable for peanut crop at the current farm gate price.

Table 7 Partial budgeting analysis of phosphate fertilizer on peanut crop in the alley and the non-alley plots.

	Fertilizer treatment	
	Phosphate	No-phosphate
1 Average yield (kg/ha)	694.23	429.80
2 Revenue (B/ha) (price of peanut = 26 B/kg)	18,049.20	11,174.80
3 Added revenue (B/ha)	6,874.40	-
4 Added cost (B/ha)		
-Labor cost	172.30	0
-Fertilizer cost	1,061.59	0
-Total cost	1,233.89	0
5 Marginal rate of return (%)	557.13	-

5.2 The late rainy season soybean experiment

5.2.1 Yield and yield component

The effect of fertilizer on soybean yield and yield components in both the alley and the non-alley plots are shown in Table 8. The application of either phosphate fertilizer alone at 122 kg/ha or compound fertilizer 12-24-12 at 281 kg/ha did not provide significantly higher yield than the control. Only the treatment with fertilizer 16-20-0 at 234 kg/ha showed higher yield than the control, with average yields of 1286 kg/ha and 1771 kg/ha in the alley and the non-alley plots respectively.

Soybean yield in the alley plots were lower than non-alley plots because of shading effect from the hedgerows and fruit trees. Instead of having more growth in reproductive stage, soybean plant in alley plot produced more biomass in vegetative stage. This result would be more clearer when we considered together with the result of soybean dry matter yield.

The fertilizer 16-20-0 also significantly increased the number of pod per plant and 100 seed weight over the control, averaging 14.6 pods per plant and 12.6 g seed weight in the alley plot, and 22.8 pods per plant and 13.5 g seed weight in the non-alley plot (Table 8).

Table 8 Effect of fertilizers on yield and yield components of soybean grown in the alley and the non-alley plots.

Fertilizer	Seed yield (kg/ha)	Plant/m^2	Pod/plant	Seed/pod	100 seed wgt.(gm)
Alley plot					
Control	807.00	60.20	9.20	1.00	11.25
0-46-0	935.00	60.20	10.60	1.40	11.14
16-20-0	1286.00	59.80	14.60	1.20	12.61
12-24-12	1047.00	59.80	13.60	1.00	11.94
Mean	1019.00	59.80	12.00	1.15	11.74
CV (%)	17.45	4.70	16.90	27.50	3.90
LSD 0.05	245.00	NS	2.80	NS	0.63
Non-alley					
Control	866.00	51.60	11.60	1.80	12.44
0-46-0	1195.00	55.00	16.20	1.00	12.74
16-20-0	1771.00	54.80	22.80	1.00	13.54
12-24-12	1394.00	55.60	17.00	1.00	13.13
Mean	1306.00	54.25	16.90	1.20	12.96
CV (%)	34.59	17.90	20.40	18.60	4.10
LSD 0.05	624.00	NS	4.80	0.30	0.73

5.2.2 Soybean dry matter yield

Soybean dry matter yields in the alley plot were significant higher in the 16-20-0 and 12-24-12 treatments than the control plot at R2, R5 and R8 stages (Table 9). Fertilizer 16-20-0 contributed the highest stem dry matter yield at R8 stage which was 3,032 kg/ha. Soybean plants receiving the 16-20-0 and 12-24-12 treatments grew taller than the control.

Table 9 Effect of fertilizers on dry matter yield and plant height of soybean at different stages of growth in the alley and the non-alley plots.

Fertilizer	Dry matter yield (kg/ha)					Plant height (cm)		
	R2	R5		R8		R2	R5	R8
		Stem	Pod	Stem	Pod			
Alley plot								
Control	717	1,111	352	2,084	807	-	-	32.6
0-46-0	723	1,575	494	2,287	935	-	-	34.3
16-20-0	1,330	2,364	653	3,032	1,286	-	-	40.0
12-24-12	1,207	1,893	734	2,567	1,046	-	-	37.6
Mean	994	1,736	558	2,493	1,019	-	-	36.1
CV (%)	13.01	29.40	24.40	10.80	1.70	-	-	8.6
LSD 0.05	207	815	217	356	245	-	-	4.3
Non-alley								
Control	724	690	306	975	865	-	-	28.7
0-46-0	851	1,182	401	1,514	1,195	-	-	30.9
16-20-0	896	1,646	411	2,093	1,771	-	-	36.8
12-24-12	886	1,677	429	1,629	1,394	-	-	34.0
Mean	839	1,299	387	1,553	1,306	-	-	32.6
CV (%)	14.8	28.80	27	25.90	34.60	-	-	7.5
LSD 0.05	NS	748	NS	553	622	-	-	3.4

In the non-alley plot the difference in dry matter yield could be seen at R5 and R8 stage. Both in the 16-20-0 and 12-24-12 treatments had higher stem dry matter yield and plant height than the control plot.

5.2.3 Nutrient composition

In the alley plot (Table 10), the fertilizer treatments did not significantly affect the nitrogen concentration of soybean plant at R2, R5 and R8 stages of growth. The average nitrogen concentration of 4.20 percent at flowering period was considered to be adequate for normal growth. The average seed nitrogen concentration of 6.50 also indicated that nitrogen was not deficient. However, in the non-alley plot, the fertilizers 16-20-0 and 12-24-12 significantly increased the nitrogen concentration of soybean plant as compared to the fertilizer 0-46-0 and the control at flowering period, but the seed nitrogen concentration was not affected by the fertilizer treatments, averaging 6.50 percent.

The phosphorus concentration at R2 stage in the control was significantly lower than the fertilizer treatments in both the alley and non-alley plots, and it was not sufficient with 0.20-0.22 percent. The seed P concentration was shown to be significantly increased by the fertilizer treatments only in the non-alley plot, and yet the concentration range of 0.49 to 0.54 percent was still below the minimum level of 0.60 percent.

Table 10 Effect of fertilizers on nutrient content of soybean at different stages of growth in the alley and the non-alley plots.

Fertilizer	N (%)					P (%)					K (%)				
	R2	R5		R8		R2	R5		R8		R2	R5		R8	
		Stem	Pod	Stem	Seed		Stem	Pod	Stem	Seed		Stem	Pod	Stem	Seed
Alley plot															
Control	3.90	2.70	3.40	0.53	6.50	0.20	0.12	0.29	0.02	0.56	1.75	1.50	1.50	1.26	1.70
0-46-0	4.10	3.00	3.60	0.56	6.50	0.30	0.16	0.31	0.03	0.52	1.89	1.50	1.63	1.33	1.70
16-20-0	4.30	2.70	3.40	0.58	6.40	0.37	0.24	0.39	0.03	0.62	2.07	1.50	1.78	1.40	1.70
12-24-12	4.30	2.80	3.60	0.57	6.50	0.35	0.22	0.39	0.03	0.58	2.04	1.70	1.78	1.40	1.60
Mean	4.20	2.80	3.50	0.56	6.50	0.30	0.19	0.34	0.03	0.57	1.94	1.60	1.67	1.35	1.60
CV (%)	7.20	6.20	4.90	9.20	3.60	0.80	27.20	12.90	14.30	11.20	3.00	5.70	5.90	5.50	3.20
LSD 0.05	NS	NS	NS	NS	NS	0.04	0.008	0.007	NS	NS	0.09	NS	0.157	0.157	NS
Non alley															
Control	3.21	3.40	3.70	0.63	6.40	0.22	0.16	0.31	0.04	0.40	2.33	1.56	1.74	1.50	1.60
0-46-0	3.31	3.60	4.00	0.72	6.60	0.29	0.27	0.44	0.06	0.49	2.38	1.73	2.11	1.80	1.60
16-20-0	4.42	3.50	3.80	0.78	6.50	0.37	0.30	0.48	0.07	0.54	2.65	1.90	2.21	1.60	1.60
12-24-12	4.41	3.30	3.70	0.69	6.60	0.39	0.28	0.46	0.05	0.54	2.58	1.86	2.22	1.60	1.60
Mean	3.84	3.50	3.80	0.71	6.50	0.32	0.25	0.42	0.06	0.49	2.49	1.76	2.07	1.60	1.60
CV (%)	8.04	8.80	5.00	10.70	2.60	12.51	10.77	8.40	21.60	7.20	5.00	4.00	4.30	13.30	2.20
LSD 0.05	0.62	NS	NS	NS	NS	0.08	0.05	0.07	0.02	0.05	0.25	0.14	0.177	NS	NS
Nutrient concentration															
	(1)				(2)	(1)			(1)	(2)	(1)	(1)	(1)		(1),(2)
minimum	1.2-3.5	-	-	-	6.50	0.25-0.35	-	-	0.05	0.60	0.30	0.30-3	0.8-3	-	1.60
optimum	-	-	-	-	-	-	-	-	0.25-0.35	-	0.7-2	-	-	-	-
maximum	-	-	-	-	-	-	-	-	0.60	-	4.5	-	-	-	-

Note : (1) Ohrogge, A.J. 1967
(2) Hume et al., 1985

The fertilizer treatments significantly increased the potassium concentration of soybean at R2 and R5 stages in both the alley and the non-alley plots, but the overall concentration was at the acceptable range.

Nutrients uptake in the alley and the non-alley plots had showed that the fertilizer 16-20-0 had increased nitrogen, phosphorus and potassium uptake more than the other fertilizer treatment (Table 11). Additional nitrogen would increase nitrogen uptake and also help plant to absorb more phosphorus and potassium. Therefore, both phosphorus and nitrogen were important for soybean.

Table 11 Effect of fertilizers on nutrient uptake of soybean seeds in the alley and the non-alley plots.

Treatment	Yield (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Alley				
Control	807	52.46	4.51	13.72
0-46-0	935	60.78	4.86	15.90
16-20-0	1286	82.30	7.97	21.80
12-24-12	1046	67.99	6.06	16.74
Nutrient components in soybean seeds [1]	1000	65	6	16
Non-alley				
Control	865	55.36	3.46	13.84
0-46-0	1195	78.87	5.86	19.12
16-20-0	1771	115.11	9.56	28.34
12-24-12	1394	92.00	7.53	22.30

Note : (1) Hume et al. , 1985

5.2.4 Economic consideration of soybean

Economic assessment for the effect of different types of fertilizer use on soybean was conducted by using the same method as peanut. Fertilizer type 16-20-0 could produced the highest yield of 1,528.5 kg/ha while 12-24-12 which was normally used by farmers had produced the yield of 1,220.5 kg/ha. 16-20-0 also gave the highest revenue, added revenue and marginal rate of return of 25,480.10 , 11,535.64 (baht/ha) and 717.16 percent respectively (Table 12). The values were high because price of soybean seed from late rainy-season especially CM60 variety in this area was high, which was about 16.67 baht/kg. Comparing between 0-46-0 and 12-24-12, 12-24-12 could produce higher yield but it also used higher cost. The marginal rate of return of both treatments was not different. Therefore, application of 16-20-0 fertilizer would be the most appropriate practice.

Table 12 Partial budgeting analysis of fertilizer treatment on soybean in the alley and the non-alley plots.

Data		Fertilizer treatments			
		Control	0-46-0	16-20-0	12-24-12
1. Average yield	(B/ha)	836.50	1,065.00	1,528.50	1,220.50
2. Revenue (price of soybean = 16.65 B/ha)	(B/ha)	13,944.46	17,753.55	25,480.10	20,345.74
3. Added revenue	(B/ha)	-	3,809.09	11,535.64	6,401.28
4. Added cost	(B/ha)				
-Fertilizer cost		0	1,037.32	1,519.02	1,734.56
-Labor cost		0	89.50	89.50	89.50
-Total cost		0	1,116.82	1,608.52	1,824.06
5. Marginal rate of return (%)		-	341.07	717.16	350.90

5.2.5 Soybean production in late rainy season on steep land

Two villages Ban Huay Som Sook and Ban Muang Kha which were near the experimental site were surveyed for grain yield of rainfed soybean. Both villages were located about 500-600 m above sea level. The rainfed soybean was sown from early August to mid-September on the steep land. All farmers had adopted most recent high yielding variety, CM 60, as the seed produced was in high demand for the subsequent dry season planting in the lowland. As planting area was limited, farmers did follow the recommended practices with type of fertilizer such as 12-24-12, and appropriate pest and weed control, aiming to maximize the yield as well as the economic return. It was noted that over 60% of farmers at Ban Muang Kha used herbicide for weed control, while at Ban Huay Som Sook, farmers preferred to control weed by hand weeding.

Farmers were well aware of importance of rhizobium inoculation, however the inoculant was not easy accessible. Farmers claimed that in the 1990 growing season, they had overseeded to ensure good stand establishment, as the seed quality was not reliable. It was learnt that most farmers kept their own seed from the preceding dry season harvest. Proper technique of drying and storage was known to farmers through the training provided by the Appropriate Technology Association, an non-governmental organization currently active in the area (Table 13).

Table 13 Farmers management of soybean plots on the steep land in late rainy season 1990.

		Huay Som Sook	Muang Kha
1	Number of farmers	10	15
2	Range of sowing date	1 Aug - 2 Sep	1 Aug - 15 Sep
3	Range of harvesting date	3 Nov - 3 Dec	9 Nov - 10 Dec
4	Planting area (rai/farmer) (or ha/farmer)	1 - 5 0.16 - 0.80	1 - 3 0.16 - 0.48
5	Seed variety	CM60	CM60
6	Amount of seed used (kg/rai) (or kg/ha)	11.2 - 18.7 70 - 116.88	12 - 22.5 75 - 140.63
7	Rhizobium (% of farmers used)	50	20
8	Fertilizer		
	- % of farmers used	90	85.7
	- Grade	12-24-12	12-24-12
9	Pesticide		
	- % of farmers used	90	100
	- Frequency (time)	1 - 3	1 - 5
10	Weeding		
	- By hand (% of farmers)	90	28.6
	- Herbicide (% of farmers)	0	21.4
	- Used both (% of farmers)	0	42.9
	- No weeding (% of farmers)	10	7.1
	- Frequency (time)	1 - 2	1 - 4

Table 14 showed the soybean yield and yield components averaged from 25 samples through crop cutting. The results indicated that both villages had potential to produce high soybean yield at the late rainy season, with maximum yield over 2.0 t/ha. Samples of high yields normally derived from the mid-August sowing when moisture was adequate for the whole growing season. The average yield obtained from Ban Huay Som Sook was higher and variable than those obtained from Ban Muang Kha, presumably due to higher plant density.

Table 14 Soybean yield and yield components in late rainy season (1990) from farmers' field on steep land.

	Plant/ m^2	Plant height (cm)	Node/ plant	Pod/ plant	Pod/ node	Seed/ pod	Seed/ m^2	100 seeds weight(gm)	Yield (kg/ha)
Ban Hauy Som Sook									
Max	63.00	61.30	12.00	37.00	3.08	2.15	2,387	14.12	2,029
Min	25.00	34.30	8.00	14.00	1.75	1.87	1,165	11.44	942.3
Mean	36.80	42.94	10.20	24.10	2.40	2.03	1,739	13.03	1,774
S.D.	11.53	8.63	1.40	6.80	0.43	0.10	357.6	0.93	358.1
CV(%)	31.30	18.63	13.73	28.22	17.92	4.93	20.56	7.14	20.19
Ban Muang Kha									
Max	43.00	56.25	12.00	50.00	5.00	2.18	3,247	14.71	2,049
Min	21.00	34.60	10.00	16.00	1.60	1.63	719	10.66	698.7
Mean	32.00	47.34	10.93	31.33	2.87	1.87	1,863	12.80	1,494
S.D.	7.20	6.40	0.80	8.12	0.77	0.16	653.1	1.45	426
CV(%)	22.50	13.52	7.32	25.92	26.86	8.58	35.06	11.33	28.51

5.3 Hedgerows component

5.3.1 Leucaena arrangement

The alley field in experimental area have three components which are leucaena hedgerows, field crops and fruit trees. The ratio of cultivated land to these crops was 3 to 5 to 2. One hedgerow had two rows of leucaena with spacing 50 cm., and the spacing between hedgerows was 4-6 m. Plant density in one row was 14 plants per 1 m. For this system arrangement, the total length of leucaena hedgerows were 1,951.85 m./ha and total plants number were 54,652 plants/ha.

5.3.2 Biomass production

Leucaena was pruned at 50 cm height before planting of the cash crop and during crop growth. Pruning frequency was about 3-4 times/year. Under this management, leucaena could produce 15.22 t/ha/year of stems and branches and 18.75 t/ha/year of fresh leaves or 5.22 t/ha/year of dry leaves.

5.3.3 Nutrient yield

Plant analysis showed that leucaena leaves consisted of 3.32 % nitrogen, 0.20 % phosphorus and 2.06 % potassium. Therefore the nutrient production which could have returned to the soil would be 173.30 kg nitrogen/ha/year, 10.44 kg phosphorus/ha/year and 107.53 kg potassium/ha/year.

5.4 Soil component in experimental area

5.4.1 Soil loss prevention

In early rainy season during peanut crop, soil movement was monitored every 2 weeks from June 24 to August 18, 1990. In the alley plot (Figure 3), and the non-alley plot (Figure 4), the treatment with leucaena mulching showed lower amount of cumulative soil loss than non-mulching plot. However this result was not significantly different because of high variability (Appendix Table E-1) resulting from the staking technique.

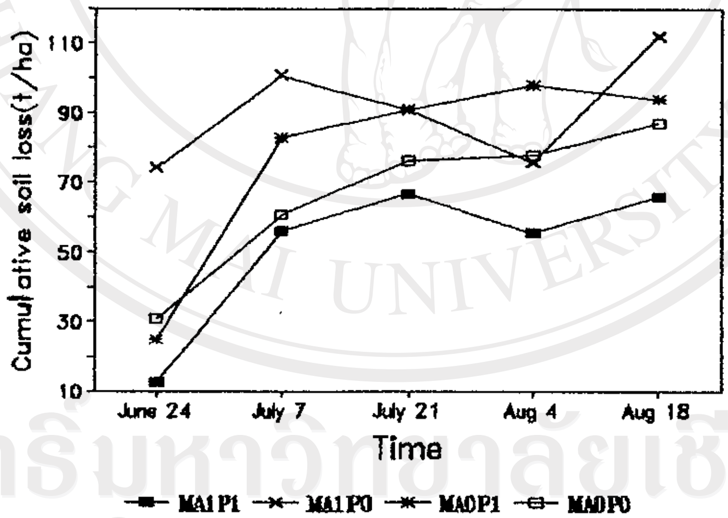

Figure 3 Cumulative soil loss (t/ha) during peanut crop in alley field

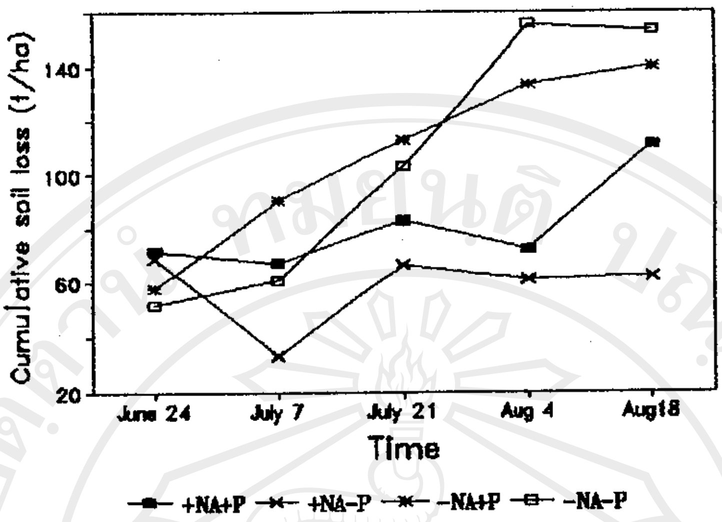

Figure 4 Cumulative soil loss (t/ha) during peanut crop in non-alley field.

It was observed that the maximum amounts of cumulative soil loss in the alley and non-alley plot were 112 and 158 t/ha during the high rainfall period in August.

The monitoring of soil loss in the following soybean crop was disrupted, as the surface soil was disturbed by fertilizer application and supplementary irrigation. The analysis was then abandoned.

5.4.2 Soil moisture distribution

Measurement of soil moisture content by weight was monitored every two weeks from June to September and from September to December during peanut and soybean growing seasons,respectively.

During the peanut growing season in the alley plots, the average soil moisture content between 0-10 cm. soil depth were different between mulching and non-mulching plots (Figure 5a, Appendix Table E-2) while between level 10-30 cm. (Figure 5b) at level 30-50 cm. (Figure 5c), the results were not different. Effect of mulching on soil moisture retention was more distinct in the non-alley plots. The mulched plot showed higher soil moisture than the non-mulched plot between soil level 0-10 and 10-30 cm. (Figure 6a, Figure 6b, Appendix Table E-2) except level 30-50 cm. (Figure 6c).

The result indicated that under the narrow spacing between hedgerows in the alley field, the hedgerows would also have certain influence on soil moisture. Mulching would increase soil moisture,especially at surface soil.

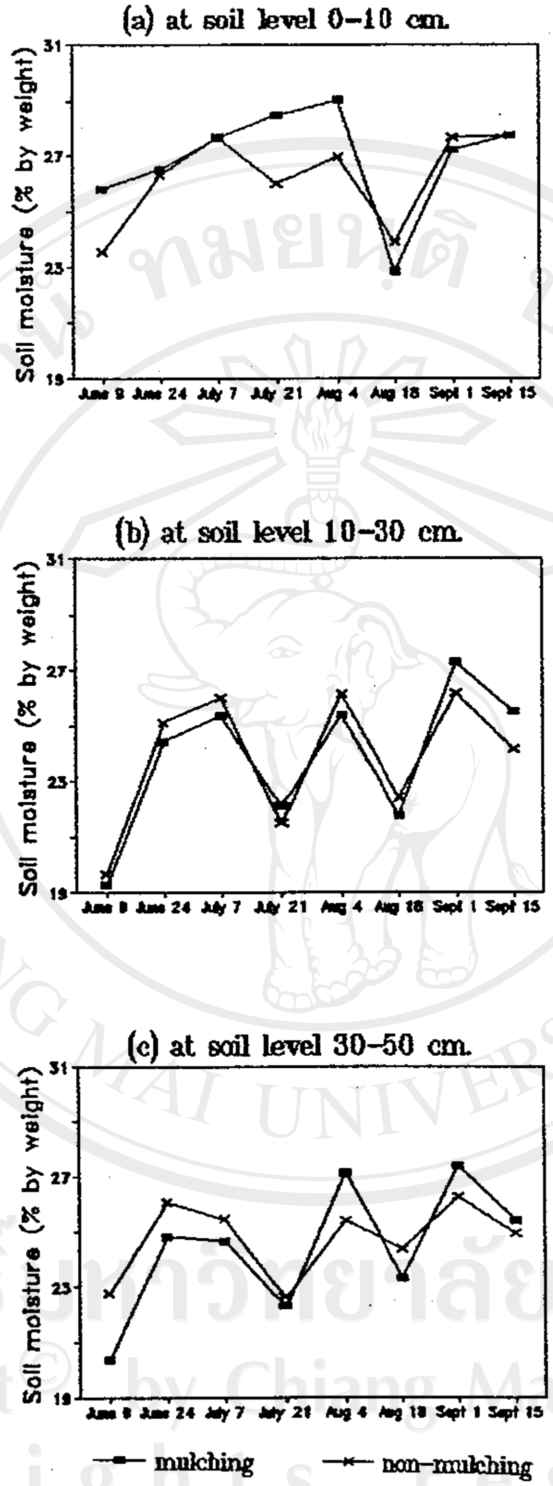

Figure 5 Soil moisture content (% by weight) between 0-10 cm.(a), 10-30 cm.(b) and 30-50 cm.(c) soil depth during peanut crop in the alley field.

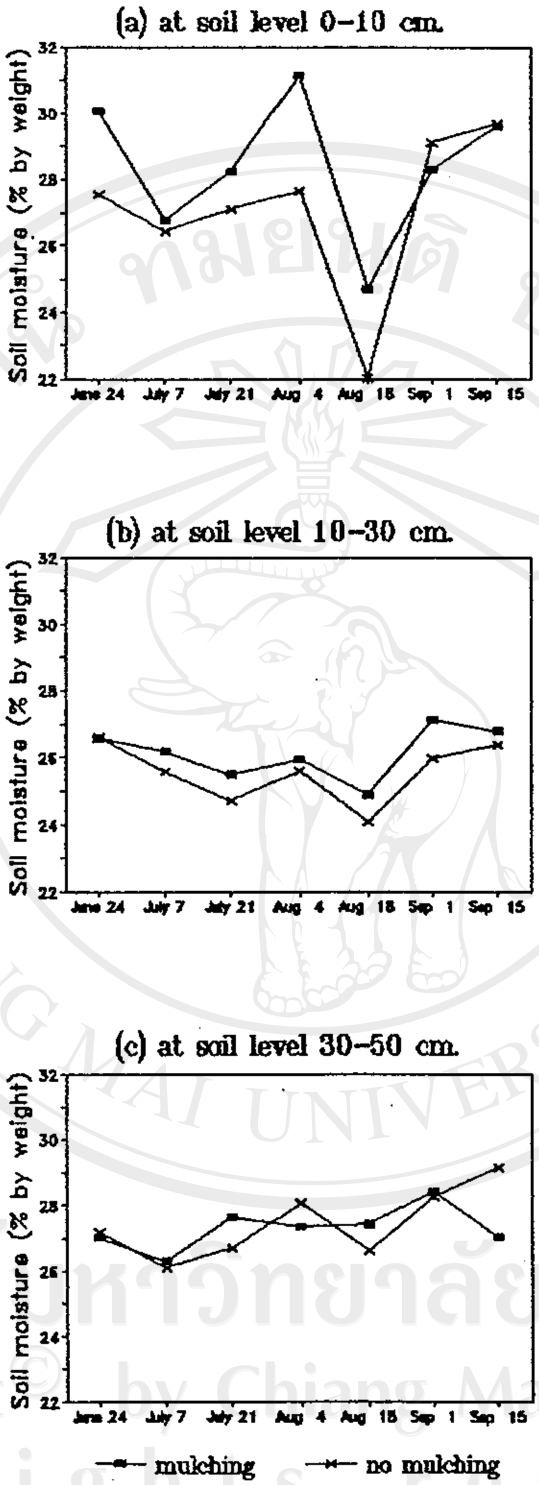

Figure 6 Soil moisture content (% by weight) between 0-10 cm.(a), 10-30 cm.(b) and 30-50 cm.(c) soil depth during peanut crop in the non-alley field.

During the soybean growing period, the distribution of soil moisture over season measured at 0-10 and 10-30 cm. depth were not affected by the fertilizer treatments in the alley plot (Figure 7a, Figure 7b, Appendix Table E-3), only level 30-50 cm. (Figure 7c) had showed difference between these two treatments. The results were not different at all in the non-alley plot (Figure 8, Appendix Table E-3)

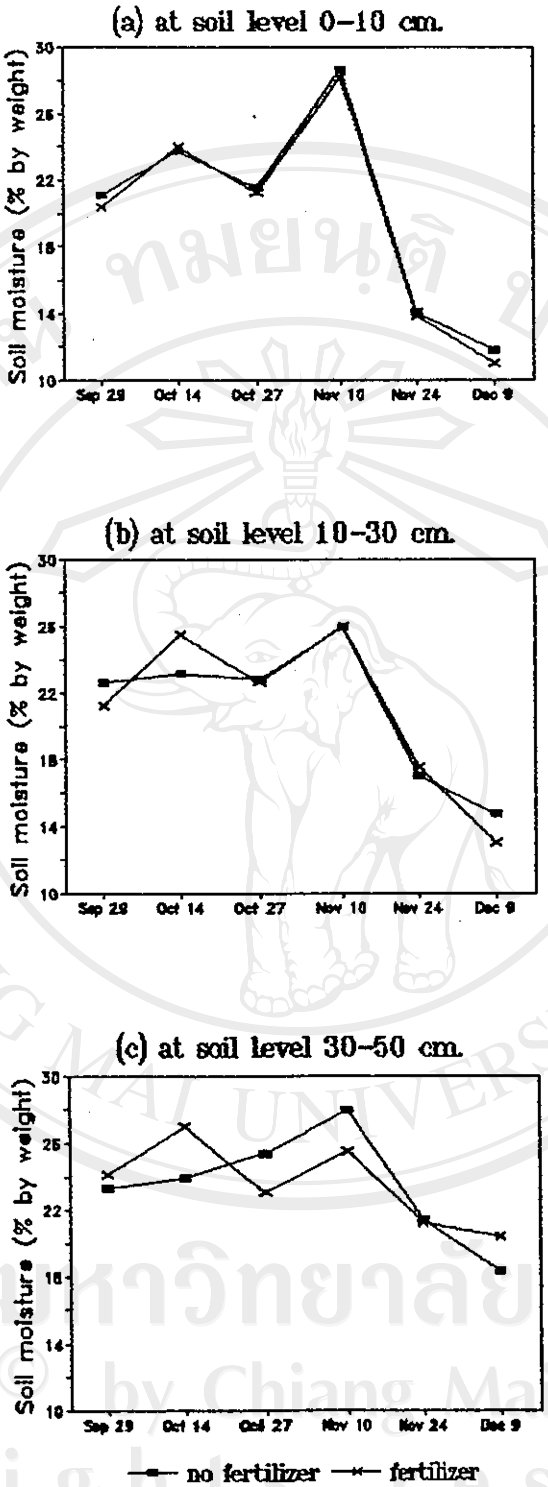

Figure 7 Soil moisture content (% by weight) between 0-10 cm.(a), 10-30 cm.(b) and 30-50 cm.(c) soil depth during soybean crop in the alley field.

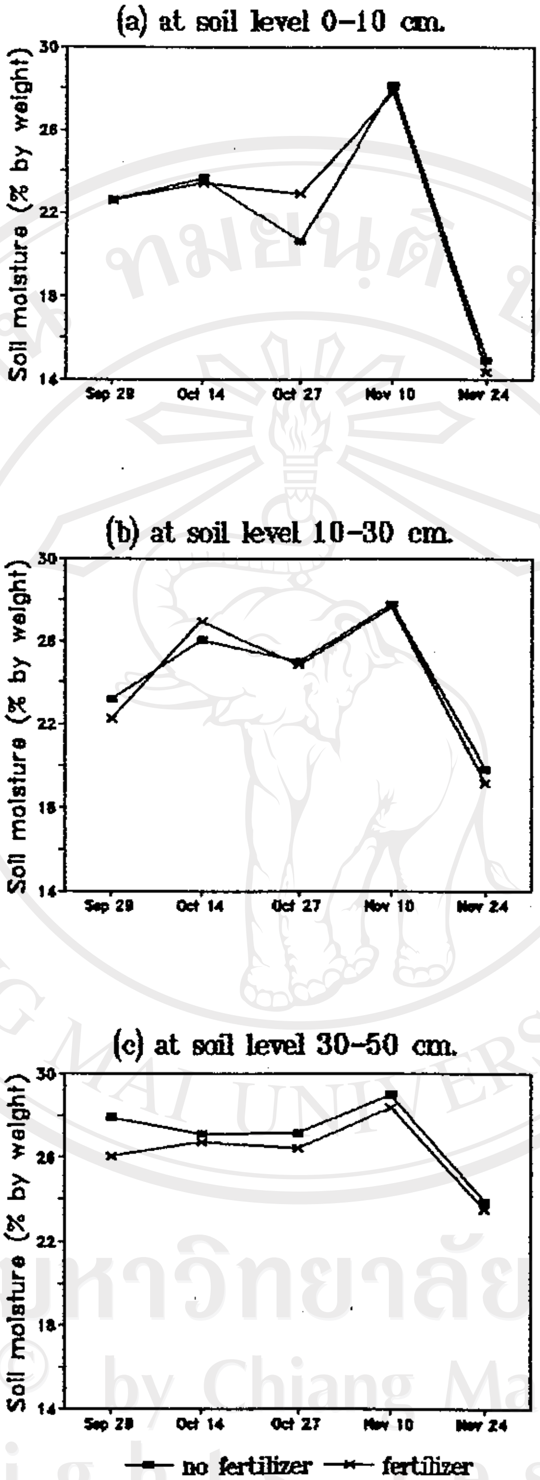

Figure 8 Soil moisture content (% by weight) between 0-10 cm.(a), 10-30 cm.(b) and 30-50 cm.(c) soil depth during soybean crop in the non-alley field.

5.4.3 Soil nutrient analysis

Data from soil analysis (Table 15) showed that, soil pH, phosphorus and potassium before growing peanut in the non-alley plots were higher than the alley plot. These two experimental plots had different crop history, the non-alley plot had been fallowed while the alley plot was cultivated for four years and growing soybean for three years. However, soil nutrients at the end of cropping season after harvesting soybean was not different except phosphorus and potassium.

Table 15 Soil analysis from the alley and the non-alley plots at soil level 0 - 20 cm.

Time	pH	OM (%)	N (%)	P (ppm)	K (ppm)
Alley farm					
Year 1990 (before peanut)	5.52	2.95	0.14	2.18	201.3
Peanut 45 DAP	5.68	-	-	2.48	-
After peanut	5.71	2.77	0.12	3.10	156.7
After soybean	5.75	2.76	0.12	6.50	148.8
Non-alley farm					
Year 1990 (before peanut)	6.17	2.70	0.12	3.80	250.0
Peanut 45 DAP	6.54	-	-	5.11	-
After peanut	6.25	2.44	0.11	4.70	215.6
After soybean	5.75	2.76	0.12	9.94	148.8

Soil pH from this experimental area at different period was higher than the critical level of 5.5 for leguminous crop. If soil pH level above 5.0, the addition of fertilizer would have impact on crop yield (Tiaranan et al., 1983). After harvest second crop soil organic matter was still maintained at 2.76 percent. Tiaranan et al.(1983) defined three levels of soil organic matter for soybean as low, medium and high level at value 1, 1-3 and 3 percent respectively. Therefore, organic matter at the site was considered to be adequate for soybean production

The use of fertilizers had increased soil phosphorus from 2.18 to 6.5 ppm. in the alley plot and from 3.8 to 9.94 in the non-alley plot. The critical level of available phosphorus for legumes is considered to be about 8 ppm. (Songchao, 11988 ; Tiaranan et al., 1983). However, Hiranburana (1986) found that under upland condition, soil containing less than 15 ppm. extractable phosphorus should be supplied with phosphate fertilizer. Therefore, phosphorus in this area was still insufficient.

Potassium was reduced to 148.8 ppm. after the harvesting soybean but the value was still higher than the critical values which were 40 ppm. for several leguminous crops and 30 ppm. for peanut (Songchao, 1988 ; Tiaranan et al., 1983), so the amount of potassium was in excess in this area. Based on this soil analysis, some additional fertilizer still needed for the next leguminous crop. Phosphorus would be the major nutrient requirement and nitrogen might be the minor one.

5.5 Labor management

5.5.1 Management of farm household labor

A detailed record of labor utilization for year-round activity was taken from the farmer participation. Farmer's objectives on food and income were achieved from agricultural activities. About 28 percent of the household labor was devoted to production of rice-soybean cropping pattern on terracing lowland paddy (Figure 9). However, this activity also required 21 percent of external labor. The other production area was on sloping land, 19 percent of farmer own labor plus 9 percent of external labor were used for the management of alley cropping and cash crops for farm income. Gathering of forest products such as bamboo shoots and occasional logging to supplement family income accounted for 9 percent of labor time. Involvement for labor exchange system in the production of food and cash crops of the farmer neighbors accounted for 11 percent. The remaining 33 percent of labor availability was mainly for non-agricultural activities such as participation in social function both at the village and district levels. It was noted that the farm family in the 1990 season did not engaged in wage earning activities.

The total external labor requirement for the year round cropping in both lowland and upland fields which was accounted for 30 percent (21+9 percent) was met by 11 percent from the exchange labor. The remaining 19 percent was hired labor which was provided by the income generated from selling of cash crops and forest products.

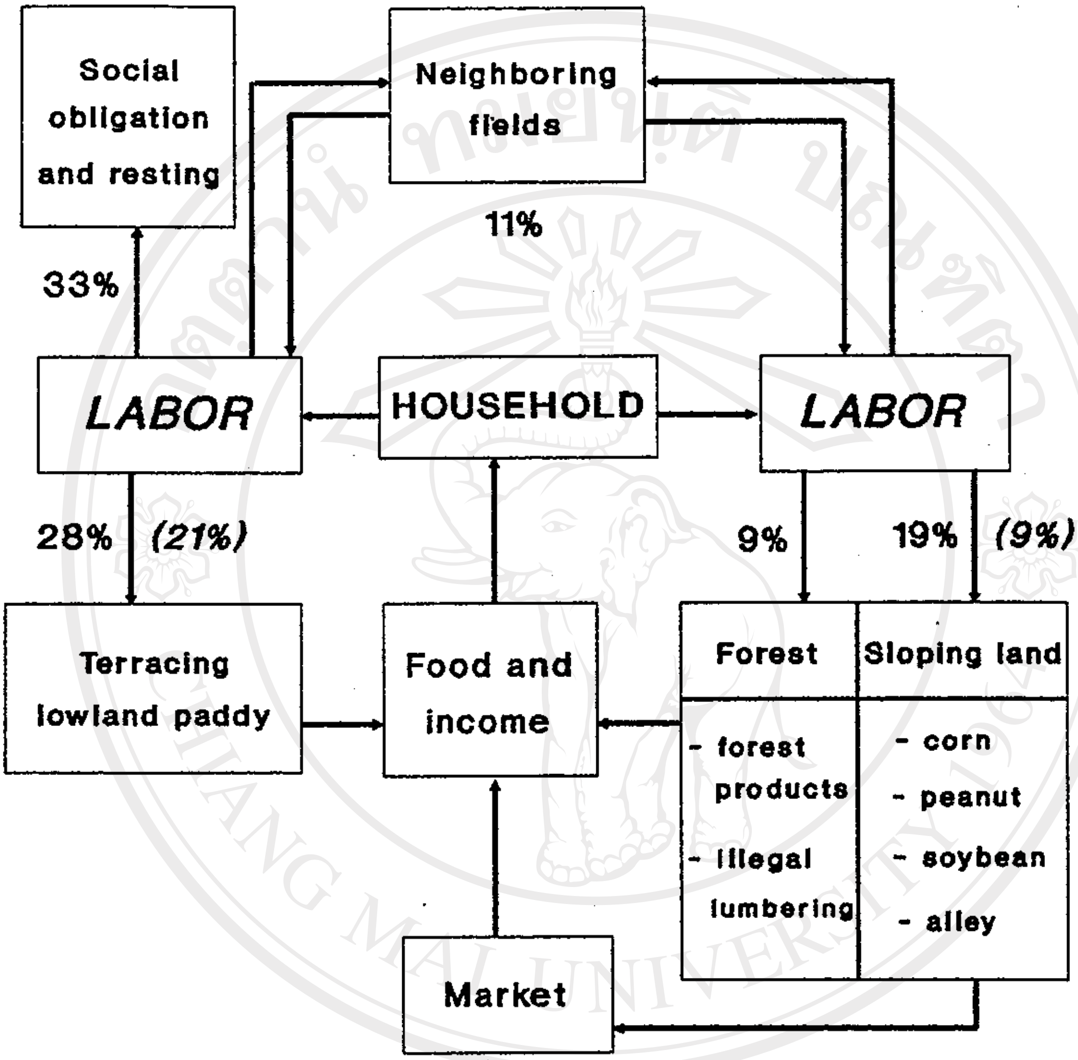

Figure 9 Labor intensive farming system of the adopter

(The (*italic number*) means external labor)

5.5.2 Return to labor in alley farm

The returns to labor for the whole cropping season in both alley and non-alley farms in the steep land were estimated (Table 16 and Appendix F). The production cost of peanut-soybean pattern in the alley farm was higher than growing upland rice and soybean in the non-alley farm which were 3,068 and 2,662 baht/ha respectively. Reducing of 0.5 ha of crop area had reduced the total income to 15,221 baht/ha although cash crops had higher price. Therefore,net income in the alley farm was lower than the non-alley farm

The total labor requirement for the peanut-soybean pattern with the leucaena hedgerows was 323 man-day/ha, while the upland rice-soybean pattern in the non-alley farm required 422 man-day/ha. The higher labor use in the latter was mainly due to high labor demand for land preparation of upland rice. The cultivation of upland rice was important for those farmers who did not have access of lowland paddy. The total net income derived from the upland rice-soybean pattern was 13,751 Baht/ha which was higher than the peanut-soybean pattern in the alley farm (12,153 Baht/ha). The system was attractive even the return to labor of 32.6 Baht/man-day was lower than the peanut-soybean pattern which received 37.6 Baht/man-day.

However, the participant farmer who adopted the alley farming practice had selected the cash cropping pattern such as peanut-soybean to provide maximum income. The system would also allow the farmer to have opportunity of using his extra labor to engage in other cash generating activities.

Table 16 Return to labor of the alley and the non-alley farms in different cropping pattern during cropping season from May to December 1990.

		Alley farm[1]	Non-alley farm[2]
Production cost			
(1) Peanut	(baht/ha)[3]	1,587.96	-
(2) Soybean	(baht/ha)	1,479.69	2,505.47
(3) Upland rice	(baht/ha)	-	156.25
Total cost	(baht/ha)	3,067.65	2,661.72
Income			
(1) Peanut	(baht/ha)	6,246.50	-
(2) Soybean	(baht/ha)	8,974.33	11,682.42
(3) Upland rice	(baht/ha)	-	4,730.95
Total income	(baht/ha)	15,220.83	16,413.37
Net income	(baht/ha)	12,153.18	13,751.65
Labor used			
(1) Peanut	(man-day/ha)	97.60	-
(2) Soybean	(man-day/ha)	225.87	149.44
(3) Upland rice	(man-day/ha)	-	272.06
Total labor	(man-day/ha)	323.47	421.50
Return to labor	(baht/man-day)	37.57	32.63

Note: 1 estimated from a participant farmer.
2 estimated from 4-6 farmers in Ban Huay Som Sook.
3 1 ha alley = hedgerows:crop area:fruit tree , 0.3:0.5:0.2 ha
1 ha non-alley = crop area 100 percent.

5.6 Farmers' opinions on conservation farming practices and prospect of alley cropping system

5.6.1 Description of the two alley farmers

Two farmers who first adopted the alley cropping system in 1986-87 has farmed in the area of forest reserve. This is a common practice for the majority of landless farmers in Ban Huay Som Sook. The two farmers aim to develop permanent agriculture by integrating perennial fruit trees and annual cash crops on those acquired land. They are aware that the chances of being approved the right to cultivate the land by the Royal Forestry Department would be high if they could show their real need and proper land use practice to the authority. The establishment of young seedlings of fruit trees was severely affected by water shortage during the dry season. They also observed the evidence of soil erosion in the village but would not realize its seriousness until both had visited the alley fields in Chiang Rai Province and had received information about the conservation function of hedgerows intercropping on the steep land.

Three species of perennial legumes were used to establish the contour hedgerows. These were pigeon pea, leucaena and gliricidia. Pigeon pea was first tested by farmers because of its fast growing habit, but the species has life span of three years and it would require re-establishment. Leucaena and gliricidia were then introduced. The participant farmer preferred leucaena because the tree could stay longer than pigeon pea and possesses smaller leaves which decompose faster than gliricidia. The farmer then increased the leucaena hedgerows with double row spacing. In 1990, the total area of steep land under leucaena hedgerow was 0.68 ha.

The hedgerows were intercropped with mixed cropping of fruit trees and legumes (Figure 10). The pruning of hedgerows was started in the second year after sowing. It was cut three times per year during cropping period in rainy season at 50 cm. above ground level and the cut materials were used for mulching on the legumes and the fruit trees.

Different field crops were sown between the hedgerows. Upland rice was sown twice. The participant farmer could get normal yield only the first crop at the second year of hedgerow establishment, and was not able to get any yield when upland rice was sown at the forth year because of shading effect from fruit trees, and weed competition. The farmer also commented that emergence of rice seedlings was also damaged by excessive soil moisture and high soil temperature caused by the leucaena mulching. The farmer found that leguminous crops were more suitable than upland rice, such as black bean, lab lab bean, mungbean, soybean and peanut. However, peanut and soybean were more profitable because of higher price, especially soybean. The upland farmers in this village would have more opportunity to produce soybean seeds in late rainy season and sell to the lowland farmers. Many species of fruit trees were arranged in the middle between the hedgerows such as lychee, longan, mango, palmelo, orange and tamarine. Coffee trees were grown at the upper side of the hedgerows.

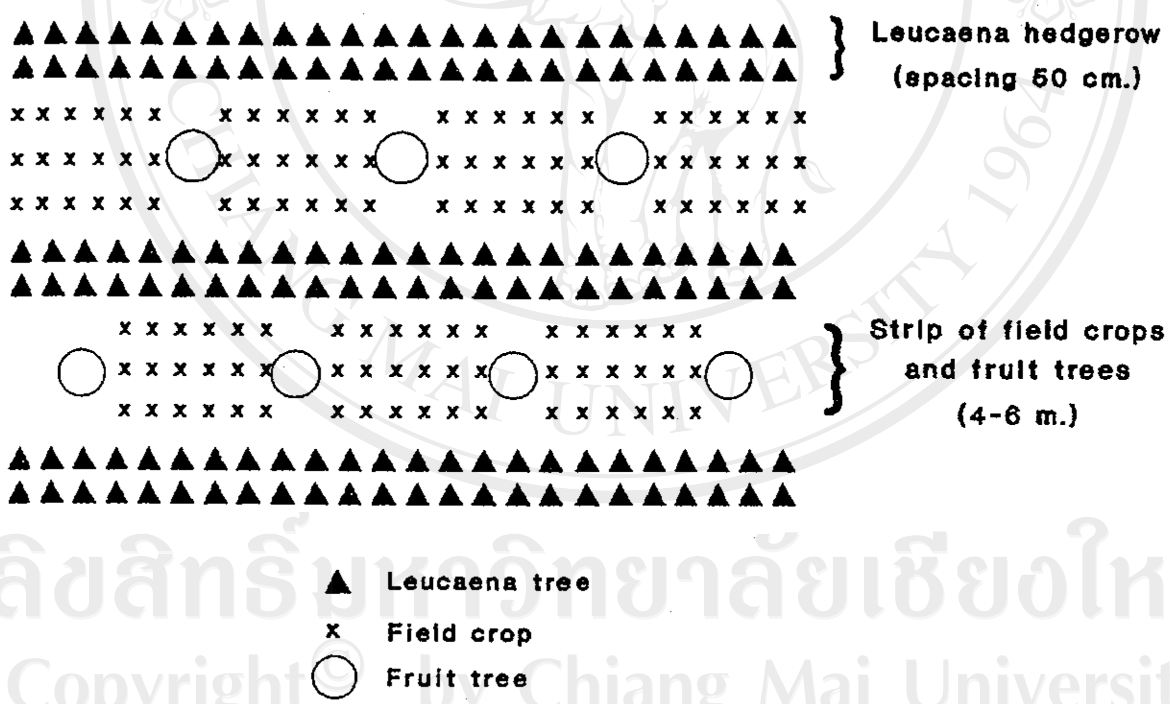

Figure 10 Intercropping of leucaena hedgerows with mixed cropping of fruit trees and field crops.

After four years, the participant farmer was convinced that the fruit trees between the hedgerows had grown and developed better than the one outside the hedgerows. In addition, field crops which were grown between the hedgerows could tolerate water stress much longer than those without the hedgerows. Effect from the hedge-barriers and yearly cultivation of annual crops had reduced the slope length and made farmer more convenient to till the land.

Although the farmer was satisfied with his conservation practices, he also accepted that the system needed more labor input for maintaining the hedgerows. For adoption of alley practice, the farmer had mentioned that he should have at least two laborers for his farming system management, if one laborer worked in the alley field, the other might need to work in the other field or go to collect forest products for food or for additional income. Farmer claimed that to establish leucaena hedgerows, he used more labor in the first year for land preparation and crop management, and used less labor in the later years when leucaena had grown enough to provide leaves for mulching, even he needed to cut leucaena every year.

The second alley farmer had adopted the practice in 1987 with the same objective of developing permanent agriculture. The farmer also observed the occurrence of soil erosion on his own field when it was cultivated continuously, and reduction of upland rice yield. He mentioned that farmers who faced erosion problem would be likely to adopt the alley cropping system. He envisaged that the system would conserve soil moisture for supporting fruit trees. The farmer had realized that the system needed more labor, input especially at the first two years. Typically, the work included clearing of old stumps, weeding to make fire break and caring of newly established hedgerows and young seedlings of fruit trees.

The hedgerows consisted of leucaena and gliricidia but the farmer preferred gliricidia because it could withstand frequent pruning and had no evidence of insect infestation. The farmer considered that gliricidia hedgerow was suitable for intercropping with fruit tree while leucaena was suitable with the field crop. The hedgerow spacing was 6 m. and between inner rows was 50 cm. The farmer had designed to have two cuttings per year during rainy season because he wanted the gliricidia to grow up as wind break for fruit trees. The cutting materials were also used as mulching. After four years of practice, the farmer had gained more experienced and better managed the alley plots, he considered that organic matter accumulation from the system could improve soil structure and increase soil fertility. He expected that fruit trees would grow faster in this alley system.

5.6.2 Farmer land holding and soil fertility problem

Two types of land use were common in the village. These were upland areas where upland rice, field crops and fruit trees were grown, and paddy fields which had two cropping patterns, rice and rice-soybean. The farm survey revealed that 45 percent of farmers had both upland and paddy fields, 30 percent had only upland, 10 percent had only paddy fields and 15 percent was landless farmers (Table 17).

Table 17 Land use in the village

Land use	% Farmers (n = 20)
Upland and paddy field	45
Upland only	30
Paddy field only	10
Landless	15

The landless farmers, however, could clear the plots on the sloping land for upland rice cultivation as there were land available. Shifting agriculture was still common among the farmers, with three to five years of fallowing period. About 80 percent of farmers felt that soil fertility in their agricultural land was not changed, only 15 percent of farmers who cultivated continuously on the same land more than two years observed that soil fertility was declining. The remaining 5 percent did not have any comments because they just migrated to the village for 10 months (Table 18).

Table 18 Farmers' opinion on soil fertility in their agricultural area

Changed in soil fertility	% Farmers (n = 20)
Increase	0
No change	80
Decrease	15
No comment	5

5.6.3 Incidence of soil erosion and farmer conservation practice

Most farmers (65 percent) had noticed the occurrence of soil erosion in their own plots or in the neighborhood (Table 19), but majority of them (69 percent) felt that the incidence was not serious although most of them had upland area (38 percent) or had both upland and paddy field (23 percent), only 31 percent thought that the erosion was a problem (Table 20).

Table 19 Farmers' observation on soil erosion in the village

Incidence of soil erosion	% Farmers (n = 20)
Already occurred	65
No evidence	35

Table 20 The degree of soil erosion problem in the village relating to farmer land use.

Degree of soil erosion	% Farmers (n=13 or 65%)				
	Landless	Paddy	Upland	Upland+Paddy	Total
Not serious	8	0	38	23	69
Serious	0	8	8	15	31

Those farmers who were aware of erosion problems thought that erosion could have negative effect on crop yield (78 percent excluding two alley farmers). The conservation practices they would like to adopt were contour planting of banana, pine apple or maize as hedgerows, as the crops could provide economic return. The use of leucaena hedgerows had lowest priority among these group. Only 22 percent of farmers did not see the immediate effect of erosion on crop yield (Table 21).

Table 21 Farmers' opinion on effect of soil erosion

Effect of soil erosion	% Farmer (n = 18)
Have effect on crop	78
No effect and not sure	22

5.6.4 Farmers land use planning

The villagers who cultivated the land would practice different cropping systems. About 55 percent would grow rice and cash crops and only seek off-farm employment when necessary. Those who grew only either rice (35 percent) or cash crop (5 percent) or did not cultivate (5 percent) would work as wage laborers in the farm or off-farm (Table 22). Most farmers would still prefer cash cropping to wage labor because they could earn lump sum at one time at harvest, even the income per day from the wage labor would be higher than cash cropping.

On the long term basis, 95 percent of the farmers had planned to establish fruit trees on their upland fields. They realized that the fruit trees would provide more stable income and higher return to land use on the uplands.

Table 22 Farmer land use anticipated

Land use planning	% Farmers (n = 20)
Short term	
rice and cash crop	55
rice only	35
cash crop only	5
not grow anything	5
Long term	
fruit trees	95
no planing	5

5.6.5 Suitability of alley cropping

All non-adopters knew the advantage of the alley system and 94 percent of these farmers had even observed the alley field in the village or the other area (Table 23). They ranked the advantages of alley cropping in descending order of importance as follows: to increase soil fertility, minimize soil erosion, conserve soil moisture, provide shading support for fruit trees, reduce weed infestation and use as fuel wood and fodder.

The two adopters considered that the hedgerows could be used as wind break and the branches were use for stake to support lychee and longan. The hedgerows were not used either for wood or animal feed.

Table 23 Number of non-alley farmers who have been to see alley field

Visiting alley field	% Farmers (n = 18)
Already visit	94
Never visit	6

The farmers also indicated the weaknesses of alley cropping system. The practice required more labor to maintain the hedgerows for timely pruning. The hedgerows could have shading effects on the annual crops such as peanut and soybean if not properly pruned. Therefore the farmers suggested that the hedgerow intercropping would be most suitable for fruit trees rather than field crops especially during dry season for it would conserve soil moisture and provide shading. The hedgerows would also reduce the crop area and at present land was already a limiting factor, additional reduction of cultivated area would decrease the total production. The leucaena hedgerow could not provide additional cash income. Leucaena seeds were not easy to harvest, and the seed market was very limited.

One alley farmer experienced that he needed more time to maintain the hedgerows. For instance with the total length of 1,952 m. (double rows) of leucaena hedgerows, he required 2 man-day for cutting and putting on his field for mulching. The other one considered that his hedgerow spacing was too narrow for intercropping with fruit trees, and if he could not collect leucaena seeds on time, it would spread out and could become a weed problem. In the case of gliricidia, pod shattering would make seed harvest more difficult.

5.6.6 Farmer adoption of the alley cropping system

About 70 percent of the non-adopter farmers were hesitated to practice the alley cropping system when it was first introduced five years ago, and the rest did not provide any comment. They argued that the technique neither had any agronomic advantages nor produced economic benefits. The management of hedgerow and subsequent lopping would take away their off-farm opportunity of which they relied as daily income. The other reasons given by the non-adopters were that they did not have access to information on alley cropping system, and they did not intend to use the land for fruit tree cultivation. The leucaena hedgerows would reduce the cropping areas and there was no marketing outlet for either leucaena seed or leucaena leaves. As far as soil and water conservation were concerned, they had never experienced drought incidence, and could not apprehend the role of alley cropping in improving soil and water conservation.

However as there were two farmers in the village adopting the practice, about 80 percent of the non-adopters would like to see the technique be further developed and verified for its adaptability in the village (Table 24).

Table 24 The future development of alley cropping

Farmers' opinion	% Farmers (n = 20)
Continue the extension work	80
No need to continue	5
No comment	15

It was indicated that, 33 percent of the non-alley adopters were interested to do alley cropping in the future because they had already see the result from the alley farmers and some of them who cultivated on the steep land had encountered the drought problem. They expected that their fruit trees would grow better in this system. There were 27 percent of the farmers still could not make any decision and 40 percent would not do alley cropping because of the weaknesses mentioned before (Table 25).

Table 25 Response of non-adopters to practice alley cropping in the coming year.

Farmers' decision	% Farmers (n = 18)
Wanted to do	33
Not sure	27
Not to do	40

5.6.7 Prospect of alley cropping

The farmer interview indicated that problems of soil erosion and declining soil fertility were not observed or "felt" by the villagers. The steep lands as occupied by the farmers were not intensively used for cultivation.

Farmers would seek off-farm employment as alternative to supplement family daily income. The hedgerow intercropping on the steep land was seen to require more labor and yet there was no economic gain from the practice. However, it was also indicated that the practice needed further development and verification to convince its advantage in conservation farming. The system would be more applicable to the fruit tree cultivation as the hedgerow could be used as wind break and the pruned biomass be used as mulch or green manure. The alley cropping system would be more acceptable by the farmers who cultivated on the more steep land, as already been shown by other development projects (Thai-Australia World Bank Land Development Project, Thai-German Highland Development Program, Care-Mae Cham Project etc.). Its potential would be more manifested on those farmers who wanted to develop permanent land use system on the sloping land.

5.7 General discussion

5.7.1 Management of cropping system

Practicing alley cropping has allowed farmers to cultivate their land every year. Different crop species can be sown between the hedgerows. However, it should meet farmers' objectives and fit with the hedgerows arrangement. In the case study, the participant farmer had found that shading effect from the leucaena hedgerows and fruit trees had reduced yield of upland rice. This had forced the farmer to change cropping pattern between the hedgerows. Reduction of cropping area and need for short term income induced the farmer to grow sequential leguminous cash crops.

The peanut and soybean cropping pattern was intercropped with leucaena hedgerows and had shown the significant yield response and economic benefit to the added fertilizers on the steep land. As the alley cropping system itself could not provide adequate nutrient supply, particularly the phosphorus content, for the normal growth of peanut and soybean, external input of phosphorus was then necessary. The pruned leucaena biomass which returned to the system annually was still unable to enhance soil productivity significantly after five years of implementation.

The farmer cropping practice was also critical for increasing crop yields. Lower plant density and wider plant arrangement had decreased peanut yield and received less benefit from fertilizer. Timely cropping schedule for the second crop, such as soybean, was an important determinant for maximum benefit. Delayed planting until October had caused reduction in seed yield by almost 40 percent.

It was observed that the plant canopy of fruit trees established between the leucaena hedgerows had shading effects on the peanut and soybean crops. Thus it was anticipated that cultivation of these annual crops would only be possible for the first six years, after which new annual crops to be included in the system should be considered.

Leucaena mulching had potential on soil loss prevention and soil moisture conservation. Pruning of leucaena hedgerows would give annual mulching material for annual cash crops and fruit trees. The weakness of staking technique on highly variation could give an inaccurate result of accumulative soil loss. The cultivation on alley field which had 28 percent slope, had caused soil erosion 112 t/ha which was higher than the acceptable value of tolerant soil loss (15 t/ha/year , Srikajon, 1984). However, this top soil movement could have been lost if it was no interruption by the hedgerows barriers. The soil would be accumulated at the upper side of the hedgerows.

5.7.2 Key factors for the functioning of farming system

Limitation of crop area had forced the farmer to work intensively on his land to meet food security and income. Higher labor input was required for the practice of alley cropping, as more labor would be invested for hedgerows establishment and pruning. The household labor was not enough for annual agriculture activities. However, the case of farmer adopter had shown that with suitable labor management, the added labor could be supported from the exchange labor system, and hired labor which came from forest income.

The gain from integrating alley cropping with fruit trees and annual cash crop had encouraged the farmer to cultivate on the same land every year and created more confidence on his hope to develop a permanent land use system.

5.7.3 Development of alley cropping

Alley cropping was not well adopted in this village because the farmer did not perceive soil erosion as their major problem. The current farming practices and wage labor had provided them with sufficient food supply and farm income. The practice of conservation farming by the farmer adopter began to shown beneficial impact on erosion control and moisture conservation. Other unexpected benefits such as role of leucaena hedgerows as the windbreak for the fruit trees was also being acknowledged by the two farmer adopters and number of neighboring farmers. The storm damage of fruit trees had been recognized by the farmers as a most devastating threat to the establishment of fruit trees on the steep land. The multiple functions of alley cropping on the steep land in the village had shown evidence that the practice would certainly meet farmers′ multiple objectives.