Chapter 4

RESULTS

4.1 Field survey's results

4.1.1 Physical characteristics

Topographically, the Northeast mountainous region of Vietnam (Figure 2) is characterized by the chains of soil and calcium rocky mountains running from North-West to South-East direction. The elevation ranges from 36 to 1900 meter above mean sea level (msl). The lower subregion is characterized by hills and narrow valleys, elevation varying from less than 200 msl. Agricultural areas are steep land on hills with slope ranging from 15 to 30 % and small terraces in valleys. In the upper subregion, elevation ranges from 200 msl to 1900 msl.

Slope increases sharply with slope greater than 30 %. Arable land is sloping, intermixing with small marginal areas. The great range of elevation from chains of mountain and valleys forms subclimates that, consequently, result in spatial and temporal diversification in agriculture.

The region is dominated by monsoonal climate. The statistics of rainfall, temperature and other climatic elements are shown in Figure 3, Appendix Table 5 and 6. There are four distinct seasons, ie. Spring (February to April), Summer (May to August), Autumn (September to

October), and Winter (November to January). In Winter the temperature ranges from 10°C to 17°C, particularly in January and February in Cao Bang, Lang Son and the upper part of Bac Thai. Low temperature in the Winter is a factor to shortens the length of growing season. In these areas, the growing season is about 210 to 240 days.

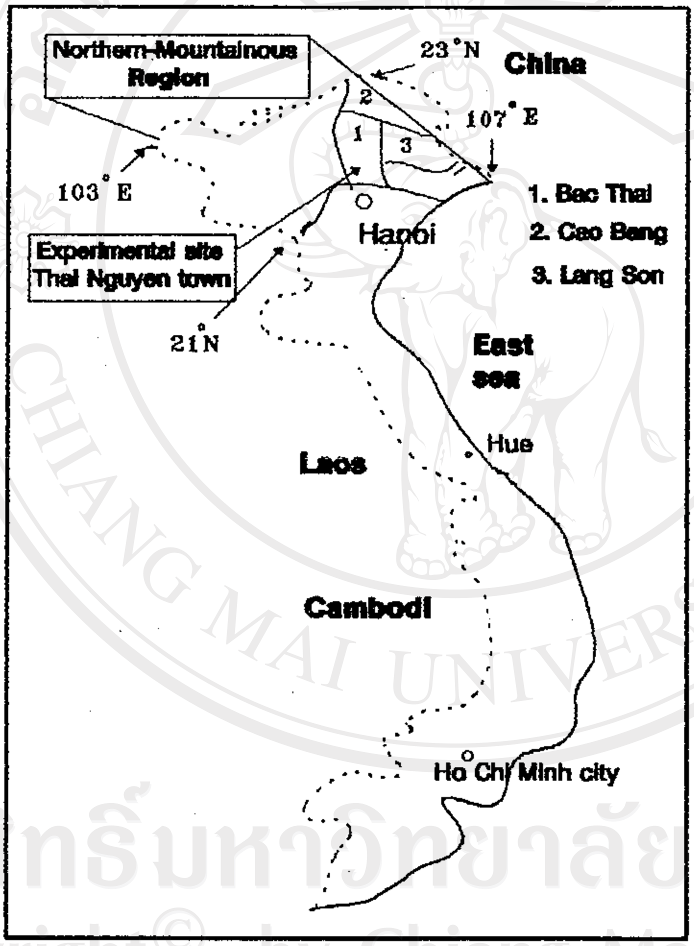

Figure 2: Map of Viet Nam shows the Northern-mountainous region and experimental site

The annual rainfall in the region is high and erratic, ranging from 1400 mm to 2000 mm. However, because of various topography there is variation in total rainfall from area to area. The side of the mountain facing the wind experiences higher rainfall than the opposite side. For example, the distance between Na Ri and Cho Don district is only 60 km, but rainfall at Na Ri is 1260 mm, while 1822 mm was recorded at Cho Don during 1991.

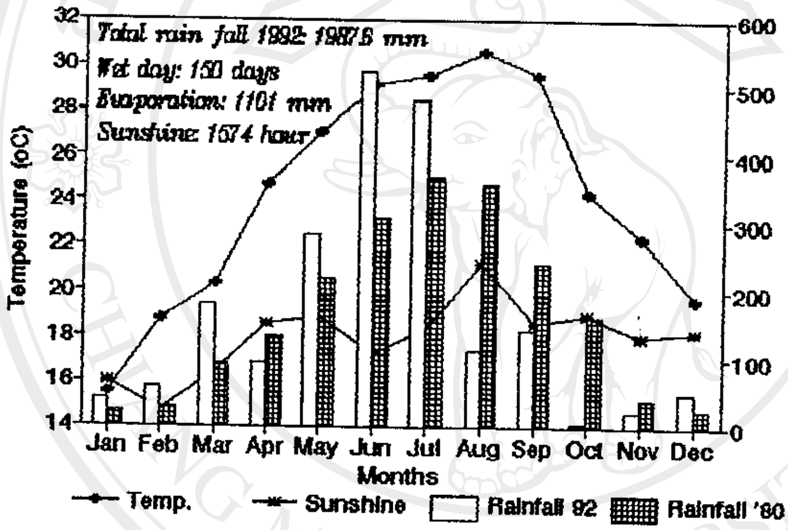

Figure 3: Climate in Thai Nguyen city of Bacthai, 1992
Source: Thai Nguyen climatic station, 1992

To assess the effects of rainfall on agriculture we consider not only rainfall but also its distribution. Rainfall is concentrated from May to September with about 75 to 85 % of total rainfall. However, the number of wet days is slightly different among the provinces, ranging from 135 - 150 days. Because of high variation of rainfall distribution in the rainy season, water loss by run off is common on sloping land, consequently there is inadequate water in the dry season.

4.1.2 Social and economic characteristics

The population of the three provinces being surveyed was 2.39 million people (Statistics book, 1992), comprising 3.5 % of total population of Viet Nam. There was total of 407,922 households (15.6 % total upland households of Viet Nam). Population consist of 43 ethnic minorities in which "Tay" and "Nung" are the two biggest groups (Table 4). Average population density ranges from 73 to 172 persons/km^2. Population distribution varied widely, high density in district towns but low in hilltribe area.

Infrastructure in the upland area is extremely poor. Roads, health care, education, information and market, etc. are inadequate. Agriculture is affected by both physical (low temperature and sloping land) and social circunstances which in turn contributes to low crop yield. Per capita average of food product was 198.0 - 238.9 kg per year (Table 4). Poverty has been common in the area. Since 1989, long term land use right was given to farmers. This is an important change in government development policy to motivate increased agricultural production.

Table 4: General information in socio-economic situation, and land distribution in Bac Thai, Cao Bang and Lang Son provinces in 1990

Items	Bac Thai		Cao Bang		Lang Son	
	Amount	(%)	Amount	(%)	Amount	(%)
A. Land distribution						
Total area (km2)	6502.90		8444.60		8167.20	
1. Agri. area (1000 ha)	117.80	100.00	70.16	100.0	95.48	100.0
Rice (1000 ha)	50.00	42.44	28.46	40.6	37.79	39.6
Field crop (1000 ha)	33.00	28.01	27.69	39.5	13.41	14.1
Fruit trees (1000 ha)	11.00	9.34	0.65	0.9	16.85	17.7
Ponds (1000 ha)	1.40	1.19	-	-	0.69	0.7
Pasture (1000 ha)	12.20	10.36	12.29	17.5	16.99	17.8
Potential (1000 ha)	10.20	8.66	1.07	1.5	9.74	10.2
2. Forest land (1000 ha)	404.00	100.00	565.50	100.0	634.06	100.0
Forest (1000 ha)	196.20	48.56	185.00	32.7	142.62	22.5
Covered percentage (%)	< 19.00	-	< 17.00	-	< 17.00	
Reforest (1000 ha)	6.70	1.66	2.50	0.44	-	-
No forest	207.83	51.44	380.50	67.3	491.44	77.5
3. Other land (1000 ha)	160.00		208.81		89.19	
B. Social aspects						
Population (1000 P.)	1060.40		518.20		624.30	
Birth rate (%)	2.10		2.40		2.30	
Density (people/km2)	163.00		69.00		76.00	
Household (1000 HH)	253.68		75.34		78.91	
Agri. labors (1000 P.)	355.73		215.67		235.05	
Agri. Pop. (1000 P.)	861.90		531.40		545.50	
Urban Pop. (1000 P.)	198.50		49.80		78.80	
Male (1000 P.)	519.60		283.30		304.10	
Female (1000 P.)	540.80		297.90		320.10	
Minorities (%)						
- Kinh	68.50		4.03		15.26	
- Tay	31.50*		43.86		33.92	
- Nung			32.85		43.86	
- Dao			10.68		3.54	
- Other			8.40		1.41	
C. Economics						
GNP (Million VN dong)	-		234347.0		349230.00	
Net income (M. VN dong)	-		155163.0		237576.00	
Food amount/capita (kg)	198.00		238.9		231.00	
Export (1000 US$)	-		548.1		2510.00	

Note: * Including Tay, Nung, Dao and others.
Source: Bac Thai, Cao Bang and Lang Son statistical division, 1992.

4.1.3 Agricultural production

4.1.3.1 Land use

Table 5 and 6 show that although the total area is very large, but arable land is small which is about 8.3 % in Cao Bang, 11.7 % in Lang Son, and 13.2 % in Bac Thai. Per capita average of arable land is about 800 to 1300 m^2.

Allocating land among crops is shown in Table 6. Because of high demand for food, area for food crops occupies most arable land while area for cash crops was small. It implies that agriculture tends to be self-sufficient in this region.

Deforestation has been serious and it seriously effected agriculture in terms of drought and soil fertility. Existing area of forest covers 22.5 - 44.5 % of forest land, in which plant covering percentage was as low as 17 - 19 %.

To focus on land use in the household, surveyed results showed that farmers had small farm size with an average of 0.81 - 0.86 ha/family. It was divided into many small plots (14 - 19 plots) and distributed intermingle among farmers. Ratio of food crops (corn, cassava, upland rice etc.) was high in all surveyed villages (Table 6). As the area used for vegetables was very small, this indicated that farmers' meals were very simple. Many farmers who live in Hai Yen and

Tong Do village collect vegetables such as young bamboos, mushrooms, flowers of plantain, etc. to substitute for domestic vegetables from the adjoining forest.

Table 5: Production of some main crops in three provinces

Crops	Bac Thai			Cao Bang			Lang Son		
	Area	Yield	Product	Area	Yield	Product	Area	Yield	Product
	('000 ha)	(t/ha)	('000 ton)	('000 ha)	(t/ha)	('000 ton)	('000 ha)	(t/ha)	('000 ton)
Rice	76.42	2.22	168.74	36.87	2.13	78.50	45.21	2.61	109.10
- L. rice	72.15	2.29	165.19	-	-	-	42.42	2.52	106.90
- U. rice	4.27	0.84	3.55	-	-	-	2.79	0.79	2.20
Corn	6.50	1.36	8.90	32.00	1.42	45.60	9.40	8.60	8.10
Cassava	4.70	10.00	47.50	1.90	8.77	16.50	3.70	11.12	41.60
S. potato	9.80	5.31	47.40	2.70	5.18	13.80	1.90	4.41	8.50
Potato	0.10	6.43	0.50	-	-	-	0.40	5.78	2.10
Peanut	5.20	0.72	3.70	0.60	52.00	0.30	1.40	0.61	1.60
Soybean	2.00	0.73	1.70	6.50	0.48	6.50	2.00	0.58	1.20
Tobacco	0.44	0.66	0.29	0.93	0.55	0.50	2.86	0.56	1.59
Sugarcane	1.14	292.6	33.33	1.03	252.00	26.24	0.79	279.30	19.17
Tea	6.00	3.0	180.00	0.26	3.00	0.79	-	-	-
Total cereal product			273.00			154.40			278.50
In which: - Rice (%)			61.80			50.50			39.40
- Others (%)			38.02			49.50			60.60

Source: Bac Thai, Cao Bang and Lang Son statistical division, 1992.

Table 6: Land use in three surveyed villages

Items	Unit	Tan Kim		Tong Do		Hai Yen	
		Amount	SD	Amount	SD	Amount	SD
People/household	people	7.13	1.5	6.64	1.54	6.67	1.91
Total area:	ha	0.81	0.10	0.86	0.17	0.82	0.15
No. of plots	plot	13.93	1.69	16.93	2.20	19.22	3.21
- Upland	ha	0.44	0.10	0.52	0.09	0.54	0.13
+ Slope < 15 %	ha	0.15	0.08	0.13	0.06	0.19	0.10
+ " 16-35 %	ha	0.16	0.06	0.14	0.10	0.21	0.11
+ " > 35 %	ha	0.13	0.05	0.24	0.08	0.14	0.04
- Lowland	ha	0.37	0.07	0.34	0.12	0.28	0.06
Land use:							
- Upland rice	ha	0.03	0.03	0.07	0.04	0.06	0.03
- Lowland rice	ha	0.37	0.07	0.34	0.12	0.28	0.06
- Cassava	ha	0.08	0.05	0.06	0.03	0.07	0.03
- Corn	ha	0.05	0.04	0.09	0.03	0.04	0.03
- Peanut	ha	0.07	0.05	0.02	0.03	0.03	0.03
- Soybean	ha	0.04	0.04	0.10	0.04	0.09	0.04
- Tobacco	ha	0.02	0.03	0.06	0.04	0.06	0.03
- Vegetable	ha	0.00	0.00	0.00	0.00	0.00	0.00
- Other crops	ha	0.13	0.06	0.15	0.09	0.17	0.13

Source: survey, 1992

4.1.3.2 Cropping systems

Complexity of topography and climate, as well as the farmers' tradition affected cropping systems. However, existing cropping systems were very simple with popularity of monoculture in upland area (Figure 4a,b). The dominant cropping systems in the area are described as follows:

1. The slash and burn practices: The main crops were upland rice, corn and mungbean, and mixing corn with soybean, mungbean or millet.

2. Field crop farming in upland: The crops grown were cassava, corn, sweet potato, tobacco, peanut, soybean, cotton in either monoculture or mixing, intercropping practices. But the latter two practices were not common in the area. Farmers grew pumpkin intercroped with corn, peanut or cowpea with cassava.

3. Lowland rice in the terraces: In rainfed area, only one summer crop rice was planted. The growing season is from April or May to October using a high yielding variety of rice such as CR203, NN8. In some areas where there are drainage facilities farmers grow spring field crops followed by summer lowland photosensitive rice such as Doanket and Baothai varieties. In the Southern region of Bac Thai where irrigation and labor are available, the intensive agriculture is practiced with double or triple cropping annually. In the lower part of Bac Thai where there is a high population, farmers have an intensive cropping system with four crops per year i.e Spring HYE rice (high yield early maturing variety of rice) - Early maturing soybean (75 days) - PSV summer rice (photoperiod sensitive variety) - vegetables.

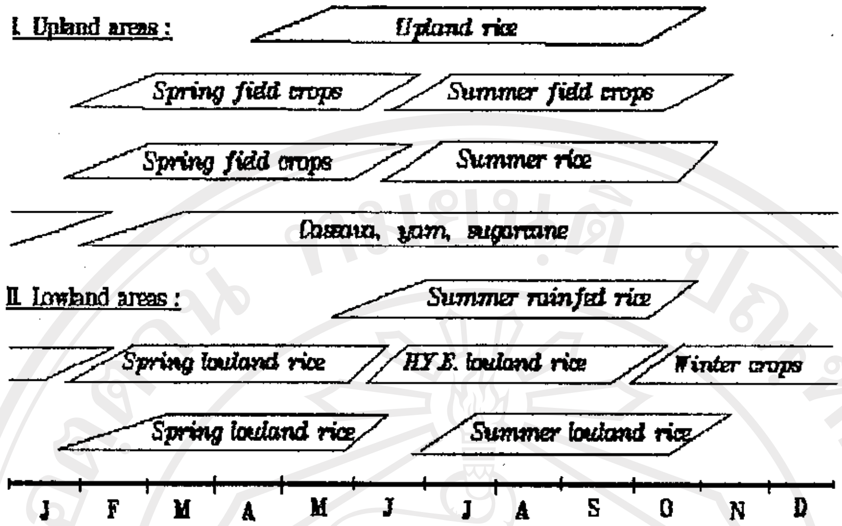

Figure 4a : Cropping systems in Bac Thai province (Survey, 1992)
Field crops : peanut, soybean, mungbean, tobacco, corn etc.

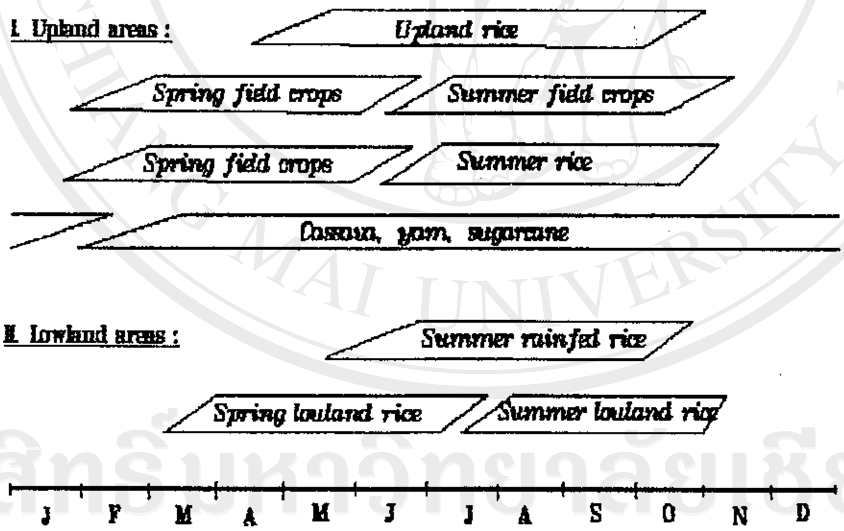

Figure 4b : Cropping systems in Cao Bang & Lang Son (Survey 199
Field crops : peanut, soybean, mungbean, tobacco, corn etc.

Common cropping systems in low land were:

- Spring field crops (eg. peanut, soybean, corn, tobacco ect.) - Summer lowland rice
- Spring lowland rice - Summer lowland rice.
- Spring lowland rice - HYE rice - winter crops.

In the area of the upper sub-regions of Lang Son and Cao Bang with low temperature, both types of temperate and tropical crops (eg. cabbage, peanut, corn ect.) can be grown.

4.1.3.3 Farmers' practices on some main crops

Results of survey on Table 7 and 8 show that lowland farmers paid attention more on rice, consequently resulted in the high yields of lowland rice (average of 3.25 ton/ha), while upland rice and other field crop yield were low (Table 7). This is because farmers in the upland area prefer traditional varieties, without or low input. The reasons for these are the matters of limited capital available for buying fertilizers. In addition, price ratio of input and output in agricultural production were not favorable for applying new technology, for example, cost of one kg urea equals 2.0 to 2.5 kg of rice. Commonly, in upland areas using one kg of urea generated only 3 - 4 kg of rice, comparing with 5 -7 kg of rice in lowland areas. However, because of living in mixed societies with lowland people who came from the Red river delta, ethnic people can see the advantage of applying new technology. For example, using modern varieties of rice that produce 2 -

3 times of yield greater than that of traditional rice varieties growing in the same condition. It contributes to changing in farmers' thinking about adopting new technology.

Table 7: Farmers' common practices on main crop production

Items	Lowland rice		Upland rice		Cassava		Corn		Peanut	
	Amount	SD	Amount	SD	Amount	SD	Amount	SD	Amount	SD
I. In Tan Kim (Bac Thai)										
- Local variety	Y		Y		Y		Y		Y	
- Modern variety	N		N		N		Y		Y	
- Ploughing times	2.20	0.40	1.00	0.00	1.00	0.00	2.00	0.00	2.00	0.00
- Harrowing times	2.20	0.40	1.00	0.00	1.00	0.00	2.00	0.00	2.00	0.00
- Sowing	Y		Y		Y		Y		Y	
- Transplanting	Y		N		N		N		N	
- Plant density (cm * cm * seed)	20*15*5		30*20*5		100*80*1		80*30*2		40*20*2	
- Animal manure (t/ha)	6.27	1.65	0.00	0.00	1.15	1.87	4.30	0.64	5.42	0.76
- Green manure (t/ha)	0.47	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- N (kg/ha)	57.33	14.82	6.00	10.20	10.00	7.84	30.50	5.68	0.00	0.00
- P_2O_5 (kg/ha)	45.33	10.87	0.00	0.00	3.08	7.22	29.5	8.50	29.17	8.62
- K_2O (kg/ha)	28.67	10.24	1.33	3.40	0.77	2.66	17.00	10.05	10.83	9.54
- Weeding times	2.27	0.44	2.00	0.00	2.31	0.46	2.80	0.40	2.25	0.43
- Pest control (time)	1.13	0.62	0.00	0.00	0.00	0.00	0.47	0.50	0.00	0.00
- Crop yield (t/ha)	3.23	0.23	0.70	0.07	10.80	1.97	1.59	0.33	0.75	0.05
II. In Tong do (Cao Bang)										
- Local variety	Y		Y		Y		Y		Y	
- Modern variety	Y		N		N		Y		Y	
- Ploughing times	2.00	0.00	0.00	0.00	1.00	0.00	1.71	0.45	2.00	0.00
- Harrowing times	2.00	0.00	0.00	0.00	1.00	0.00	1.71	0.45	2.00	0.00
- Sowing	Y		Y		Y		Y		Y	
- Transplanting	Y		N		N		N		N	
- Plant density (cm * cm * seed)	20*15*5		30*30*5		100*80*1		80*30*2		40*20*2	
- Animal manure (t/ha)	6.14	1.25	0.00	0.00	0.00	0.00	2.25	2.31	3.20	1.72
- Green manure (t/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- N (kg/ha)	35.00	12.39	0.00	0.00	1.67	3.75	17.68	9.39	0.00	0.00
- P_2O_5 (kg/ha)	24.29	17.20	0.00	0.00	2.92	5.19	12.14	12.21	6.00	12.00
- K_2O (kg/ha)	15.36	11.72	0.00	0.00	0.00	0.00	10.36	9.35	6.00	4.90
- Weeding times	2.21	0.41	1.93	0.26	2.00	0.00	2.71	0.45	2.00	0.00
- Pest control (time)	0.64	0.61	0.00	0.00	0.00	0.00	0.21	0.41	0.00	0.00
- Crop yield (t/ha)	3.02	0.22	0.70	0.22	10.17	0.99	1.39	0.21	0.68	0.04

Source: Survey, 1992
Note: Y = yes, N = no

Table 8: Farmers' common practices on main crop production (continued)

Items	Lowland rice		Upland rice		Cassava		Corn		Peanut	
	Amount	SD	Amount	SD	Amount	SD	Amount	SD	Amount	SD
III. In Hai Yen (Lang Son)										
- Local variety	Y		Y		Y		Y		Y	
- Modern variety	Y		N		N		Y		Y	
- Ploughing times	2.17	0.37	0.00	0.00	1.00	0.00	1.89	0.31	2.00	0.00
- Harrowing times	2.17	0.37	0.00	0.00	1.00	0.00	1.89	0.31	2.00	0.00
- Sowing	Y		Y		Y		Y		Y	
- Transplanting	Y		N		N		N		N	
- Plant density (cm * cm * seed)	20*15*5		30*30*5		100*80*1		80*30*2		40*20*2	
- Animal manure (t/ha)	6.94	1.43	0.00	0.00	0.22	0.53	5.07	1.71	5.36	0.77
- Green manure (t/ha)	0.56	11.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
- N (kg/ha)	51.11	16.29	0.00	0.00	6.11	8.91	29.43	7.25	0.00	0.00
- P_2O_5 (kg/ha)	38.89	12.43	0.00	0.00	0.00	0.00	15.36	12.88	22.73	18.14
- K_2O (kg/ha)	18.33	9.57	0.00	0.00	0.56	2.29	12.14	9.39	3.64	6.43
- Weeding times	2.28	0.45	1.83	0.37	2.06	0.23	2.67	0.47	0.00	0.00
- Pest control (time)	0.94	0.70	0.00	0.00	0.00	0.00	0.33	0.47	0.00	0.00
- Crop yield (t/ha)	3.23	0.23	0.66	0.08	9.94	0.97	1.61	0.47	0.63	0.09

Source: Survey, 1992
Note: Y = yes, N = no

4.1.4 Farmers' background on soil conservation

About 94 % of farmers who were interviewed agreed that their upland fertility has been decreasing. The evidence derived from an observed decreasing crop yield, soil color change from grey to lighter grey and increasing sand ratio in the surface layer. When they were asked about what caused those problems, they responded that high rainfall and land preparation in high slopes were the main reasons. Other factors such as soil types and cropping patterns were not strongly considered (Table 9). They occasionally practiced multiple cropping but in small area.

Table 9: Farmers' background on soil conservation in upland farming

Questions	% of respondents (n=48)
1. Change of soil fertility	
- Increasing	0.00
- Decreasing	93.75
- No change	6.25
2. Farmers' perception on soil erosion	
- Serious	25.00
- Moderately serious	64.58
- Less serious	10.42
3. Causes of soil erosion	
- By high rainfall	100.00
- By steep land	100.00
- By tillage	72.92
- Crop management (planting date, density, weeding etc.)	68.75
- Plot size	72.92
- Cropping Pattern	47.92
4. Applied methods of soil conservation [1]	
- Making terrace	27.08
- Gully control and making bends	31.25
- No tillage farming	0.00
- Stripcropping and grass strips	0.00
- Multiple cropping (intercropping, mix-cropping)	72.92
- Residue mulching	12.50

Source: Survey, 1992

[1] These figure show the persentage of households practice soil conservation only, regardless practicing level.

In the past when right of land use right had not been given by government, the farmer did not care about land conservation. At present, however, with new recent land use right policies , farmers pay much more attention to maintaining their land productivity with conservation in mind.

[1] These figures show the percentages of households practice soil conservation only, regardless practicing level.

4.1.5 Farmers' opinions on alley crop farming

Alley cropping is a new practice to the farmers in the area. At present, a few farmers have seen this technique, and *T. candida* which is commonly used as homegarden fences in the region. After explaining some benefits as well as its role in soil conservation, 60.42 % of respondents said that if seeds and technical guide were provided they would try. Farmers who did not want to adopt it gave several reasons such as no knowledge (94.74 %), too complicate (84.21 %), cattle encroachment (94.7 %). Other reasons were shortages of labor (31.58 %) and land (42.11 %). In most parts of the region during the dry season, farmers let their livestock graze freely after crops were harvested. This might be too difficult to protect an established hedgerow system from cattle damage in isolated plots (Table 10).

4.1.6 Farmers' opinions on cropping patterns in upland farming

Results of the survey also indicated that monocultivation is very common in the area. Farmers regarded intensive cultivation only on lowland rice, so upland farming is very simple. They preferred the crops which have stable yield and need low input as well as those which fit their *in situ* food requirement. Multiple cropping was rarely seen in a large area. However, there were some cropping patterns seen in some small areas such as intercroping cassava with peanut, mixing peanut with corn, corn with pumpkin, sweet potato with corn, mungbean with corn or millet, and soybean with corn.

Table 10: Farmers' opinions on alley farming (n=48)

Questions	% respondents	
1. General	Yes	No
- Have done alley cropping	0.00	100.00
- Have seen alley cropping	6.25	93.75
- willing to adopt alley cropping	60.42	39.58
2. Reasons of non-adoption	% of who did not adopt	
- No know how	94.74	
- Complication	84.21	
- Lack of land	42.11	
- Lack of labor	31.58	
- Encroachment of cattle	63.16	
- Non-beneficial in short term	94.74	
- Nutrient competition with crops	63.16	
3. Need to subsidize for the adoption	% of farmers willing to adopt	
- Seeds of T. candida	100.00	
- Technical guide	85.71	

Source: Survey, 1992

When farmers were asked about the advantages and disadvantage of multiple cropping, most farmers who had experience with the system responded positively (57.14 % - 74.29 %). However, 83 % of farmers had shown little or no experience of multiple cropping; 63 % said the system was complicated while those who practised, 33 % mentioned that lobor shortage made the system difficult (Table 11).

Table 11: Farmers' practices on cropping systems (n=48)

Questions	% respondents		
1. General	Done	Positive	Negative
- Intercropping	72.92	74.29	25.71
- Mix-cropping	14.58	57.14	42.86
- Relay cropping	0.00	0.00	0.00

2. Cropping systems	Done	Positive	Negative	to adopt	Not to adopt
- Peanut-corn sequential cropping	66.67	87.50	12.50	79.17	20.83
- Peanut-upland rice relay cropping	0.00			22.92	77.08
- Peanut-cassava intercropping	31.25	100.00	0.00	79.17	20.83
- Peanut-corn relay cropping	0.00			29.17	70.83

3. Difficulties of multiple crop farming	Yes	No
- No or little experience	83.3	16.7
- Complicated	62.5	37.5
- Lack of labor	33.3	66.7

Source: Survey, 1992

About farmers' practice and willingness to adopt new cropping patterns, 66.67 % of respondents had grown peanut-corn sequential cropping, and 31.25 % cultivated peanut-cassava intercropping and most of them responded positively. However, peanut-corn relay cropping and peanut-upland rice relay cropping received negative response. They provided reason that these systems are too complicate to practice.

4.2 Field experiment's results

4.2.1 Productivity of crops

4.2.1.1 Peanut

With the purpose of seeking solution for getting high productivity and maintaining soil status, peanut was inclulted in the cropping systems in the experiment as a potential legume crop because of its popularity and adaptbility to the poor soil and climate conditions.

Results of the experiment showed that growth duration of peanut was 122 days, and the average plant height was 42.7 cm. Analysis of variance on peanut for all indicators in various cropping systems grown with and without hedgerows are presented in Table 12. The result revealed that there were significant differences in pod yield (P<0.01), green manure (fresh residue of peanut) (P<0.01), dry shoot biomass at 30 DAS and at harvesting time (P<0.01), and dry shoot biomass at 60 DAS (P<0.05). These differences resulted from effects of cropping system factor. Hedgerow factor showed non-significant on peanut growth and yield for all cropping treatments. Similar results were observed by Matthews et al., (1992) in Zambia, and Kang et al., (1985).

Treatments of peanut-cassava intercropping (+H3 and -H3) gave the lower biomass , pod yield, green yield and biomass companies to other treatments (Figure 6). This was result of lower peanut area in treatments intercropping with cassava.

Table 12: Characteristics of peanut in different treatments

TRT	Growth duration (day)	Plant height (cm)	Number of pod (pod)	100 pod weight (g)	Pod yield (kg/ha)	Green manure (kg/ha)	Total biomass (kg/ha)
+H1	122.00	44.96	4.65	104.46	1155.61	7688.47	3924.33
+H2	122.00	42.59	4.58	103.14	1002.72	6811.45	3448.41
+H3	122.00	48.06	4.92	108.67	682.44	4555.81	2321.82
+H4	122.00	42.38	4.94	106.65	1089.72	6928.39	3562.01
-H1	122.00	40.72	4.78	105.94	1206.57	7720.65	3978.60
-H2	122.00	36.94	5.22	103.45	1247.60	7646.59	4076.83
-H3	122.00	44.28	3.96	112.15	703.07	4152.25	2196.15
-H4	122.00	41.56	4.47	103.12	1139.92	8294.60	4154.49
$\bar{X}$	122.00	42.69	4.69	105.95	1028.46	6724.78	3457.83
Interaction		ns	ns	ns	ns	ns	ns
CV (%)		13.89	18.06	5.90	27.26	24.62	24.42
LSD .05		ns	ns	ns	151.58	998.75	461.48
LSD .01		ns	ns	ns	212.51	1400.20	646.97

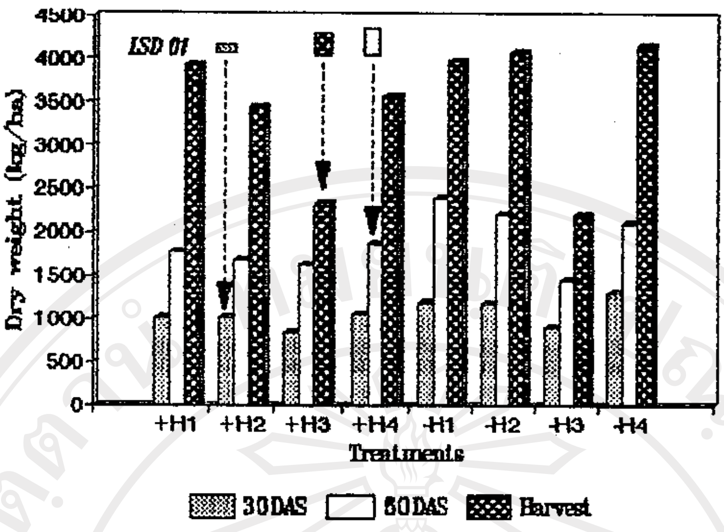

Figure 5: Biomass of peanut over time

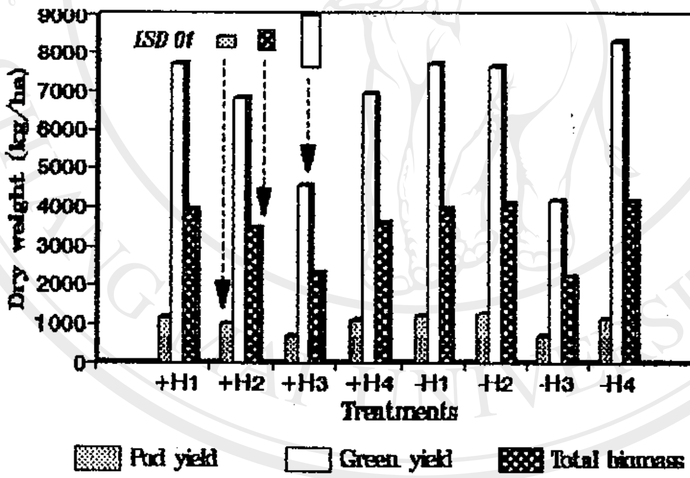

Figure 6: Peanut pod and green yields, and total biomass

4.2.1.2 Corn

Making comparison among the different characteristics of corn in various cropping treatments, Table 13 shows that alley cropping did not affect growth duration of corn while cropping system factor strongly affected it. Corn in relay cropping required a 20 days longer growth duration than sequential cropping.

Similarly, significant differences in growth duration and plant height of corn were also affected by cropping system factor ($P<0.01$). Average plant height was 29.7 cm higher in sequential cropping as compared with relay cropping.

Table 13: Characteristics of corn in different treatments

TRT	Growth duration	Plant height	Cob # /plant	Grain W. /cob	100 grain weight	Grain yield	Residue yield	Total biomass
	(day)	(cm)	(cob)	(g)	(g)	(kg/ha)	(kg/ha)	(kg/ha)
+H1	90.00	184.80	1.30	51.40	272.80	1171.00	1957.20	3128.10
-H1	90.00	182.10	1.00	43.80	275.20	1250.40	2127.40	3377.80
+H4	110.00	159.00	1.30	47.30	273.40	996.90	1494.90	2491.80
-H4	110.00	148.40	1.00	43.40	271.60	1062.30	1619.40	2681.80
$\bar{X}$	100.00	168.6	1.20	46.5	273.3	1120.10	1799.70	2929.90
Interactions		ns	ns	ns	ns	ns	ns	ns
CV(%)		11.40	14.40	14.60	1.10	12.20	22.50	17.50
LSD .05		26.80	0.20	ns	ns	72.70	446.10	503.60
LSD .01		ns	ns	ns	ns	120.50	ns	ns

Table 14: Biomass of corn at different developmental stages

(kg/ha)

TRT	30DAS	60DAS	Harvest
+H1	20.2	1744.4	3128.1
-H1	22.8	1814.1	3377.8
+H4	22.0	1036.3	2491.8
-H4	26.2	1108.9	2681.8
Mean	22.8	1425.9	2919.9
Interaction	ns	ns	ns
CV (%)	13.3	27.4	17.5
LSD .05	2.2	105.8	503.6
LSD .01	ns	175.4	ns

There were significant difference in corn residue and in total biomass in all growth stages. For the first 30 DAS (days after sowing) the alley cropping affected on dry biomass (P<0.05), but after that different cropping systems affected on it (P<0.05) (Table 14).

Grain yields in sequential cropping treatment was significantly higher than that of relay cropping treatments (P<0.01). Highest grain yield was obtained in treatment of sequential cropping without hedgerow (Treatment +H1). This probably due to competition between peanut and corn (Tsay, 1985 adapted from Ofori and Stemin 1987; Rao, 1983) in early growth period that induced relatively lower growth in later periods was thought to be responsible for the above differences. This data was evidenced by differences in biomass and cob number per plant.

drought stress during September and October might also contributed to the low yield.

Comparing corn gain yield between treatments with and without hedgrows, no significant difference was found. The similar result reported by Matthews et al., (1992). On the other hand, Kang et al., (1984) observed that the higher corn and cassava yield were obtained in alley cropping with *L. leacaena* and *G. sepium*.

4.2.1.3 Upland rice

In 1992, there was high rainfall in early season and serious drought in later, in which it strongly influenced crop's perfomance, particularly upland rice. Remarkable differences in the increase of biomass of upland rice throughout the season was observed between treatments in various stages (Table 15). At 20 DAS, 80 DAS and 110 DAS, biomass of the treatments without hedgerow was significantly higher than those in treatment with hedgerows($P<0.01$). While at 50 DAS and during harvesting time these differences were not found.

As mentioned in the above, in the early rainy season of 1992 the rainfall was much higher than that of past years. However, the amount of rainfall reduced sharply later which caused serious drought. This stress fell right in the stage of reproduction of rice. Therefore, most rice grains were unfilled.

Table 15: Growth duration and biomass of upland rice

TRT	Growth duration (day)	Biomass (kg/ha)				
		20 DAS	50 DAS	80 DAS	110 DAS	140 DAS
+H2	140.00	31.09	297.42	1078.22	1937.32	2708.90
-H2	140.00	37.35	358.02	1375.92	2385.36	3308.32
CV (%)	-	10.41	12.60	12.86	11.54	12.39
LSD .05	-	1.22	ns	40.75	156.28	ns
LSD .01	-	2.82	ns	93.99	360.48	ns

4.2.1.4 Cassava

Differences in cassava biomass between treatments with and without hedgerows were found at 200 DAS (P<0.05), but soon after there was no significant difference were found and other characteristics hardly change (Table 16). Although the number of plants in the treatment with hedgerow was lower than that without hedgerows, cassava could regulate itself by taking advantage of the light and nutrients available to produce biomass equal with those in treatment without hedgerows. Consideration of the growth of cassava components, Appendix Table 9 displayed that growth of leaves increased from the growing date to 170 DAS, then reduced, and stabilized at 200 DAS till harvest. Stem weight increased from the growing date until 230 DAS then stabilized. While root weight increased continuously from growing date to harvest.

Table 16: Characteristics of cassava in different treatments

TRT	Growth duration	Plant height	Root number	Root weight	F. root yield	Dry root yield	Total biomass
	(day)	(cm)	(#/plant)	(g)	(kg/ha)	(kg/ha)	(kg/ha)
+H3	250.00	151.30	4.44	448.34	16586.58	6850.26	9931.43
-H3	250.00	152.56	4.30	430.93	18610.41	7599.04	10889.18
CV(%)		4.00	10.97	10.75	10.75	10.06	11.71
LSD .05		ns	ns	ns	ns	ns	ns
LSD .01		ns	ns	ns	ns	ns	ns

4.2.1.5 *Tephrocia candida*

This leguminous tree seems to be a potential component of cropping system to protect soil from erosion and degradation. It was proved by average green manure (or mulches) of 6156 kg/ha/year return to soil (equivalent to 42.21 kg/ha N; 4.02 kg P_2O_5 and 6.68 kg K_2O/ha/year) (Table 17). Moreover, an unaccountable mass of organic matter in root systems was supplemented *in situ*. Especially, this is necessary for highland where soil is very poor in organic mater and nutrients, and with unfavorable conditions for input transportation. Differences in green matter, dry matter and total biomass among treatments with hedgerows was not significant.

Table 17: Biomass and contained nutrients in *T. candida*

TRT	Green matter (kg/ha)	Dry matter (kg/ha)	Fire wood (kg/ha)	Total biomass (kg/ha)	Nutrients in dry matter N	P_2O_5	K_2O	N	P_2O_5	K_2O
	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(%)	(%)	(%)	(kg/ha)	(kg/ha)	(kg/ha)
+H1	5958.75	1818.75	1370.83	3170.58	2.275	0.294	0.306	42.21	4.62	6.68
+H2	6234.38	1854.97	1303.75	3158.72	2.275	0.294	0.306	42.21	4.62	6.68
+H3	6017.08	1786.23	1245.42	3031.64	2.275	0.294	0.306	42.21	4.62	6.68
+H4	6451.67	1961.46	1353.33	3314.79	2.275	0.294	0.306	42.21	4.62	6.68
$\bar{X}$	6156.47	1855.35	1318.33	3173.68	2.275	0.294	0.306	42.21	4.62	6.68
CV(%)	6.96	5.84	10.30	5.4						
LSD .05	ns	ns	58.90	ns						
LSD .01	ns	ns	89.30	ns						

However, significant differences (P<0.01) occurred in firewood weight, in which the treatment of peanut - cassava intercropping provided the smallest firewood weight. This may be the result of the suppression of cassava canopy to the growth of *T. candida*. A taller plant of cassava might compete more strongly for light with *T. candida* (Rao, 1983; Tsay, 1985). Average yield of 1,318.3 kg firewood/ha/year is a considerable amount for farmers where the firewood supply is always inadequate. In recent years fuel-wood is often commercialized and thus can give farmers cash income. Result of producing biomass (green matter as well as firewood) of *T. candida* in the trial had proved that it is a suitable tree in poor acid soil in the region. While *L. leucaena* was poor performance in acid soil (Kang et al., 1984).

4.2.1.6 Total biomass and yields in cropping systems

A significant difference in total biomass among treatments was found. This was caused by both factors alley cropping ($P<0.05$) and cropping system ($P<0.01$). Average total biomass was 35.4 % higher in treatments with hedgerows (Table 18).

Table 18: Productivity of different components in the cropping systems

TRT	Total Biomass		Economic yield: For food		Economic yield: For cash		Residue yield: Legumes		Residue yield: Non-legumes		Fire wood	
	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)
+H1	10242.00	100.00	1171.00	11.43	1156.61	11.28	4587.47	44.79	1957.20	19.11	1370.83	13.38
+H2	9261.10	100.00	-	-	1002.72	10.83	4300.66	46.44	2708.90	29.25	1303.85	14.08
+H3	15284.90	100.00	6850.26	44.82	682.44	4.46	3425.61	22.41	3081.17	20.16	1245.42	8.15
+H4	9368.60	100.00	996.90	10.64	1089.72	11.63	4433.75	47.33	1494.90	15.96	1353.33	14.45
-H1	7356.40	100.00	1250.40	17.00	1206.57	16.40	2772.03	37.68	2127.40	28.92	0.00	0.00
-H2	7385.20	100.00	-	-	1247.60	16.89	2829.23	38.31	3308.32	44.80	0.00	0.00
-H3	11245.90	100.00	7599.04	67.57	703.07	6.25	1493.08	13.28	3290.08	29.26	0.00	0.00
-H4	6836.30	100.00	1062.32	15.54	1139.92	16.67	3014.57	44.10	1799.70	26.33	0.00	0.00
$\bar{X}$	9622.55	100.0	2366.24	20.87	1028.46	11.80	3357.05	36.79	2470.96	26.72	1318.36	12.51
Interaction		ns	-		ns		ns		ns		-	
CV(%)		29.70	-		27.26		40.94		31.26		-	
LSD(1)	.05‡	2087.40	-		ns		733.21		ns		-	
	.01	-	-		ns		1691.30		ns		-	
LSD(2)	.05	588.06	-		151.58		376.97		287.00		-	
	.01	824.42	-		212.51		528.16		402.35		-	

Note: ‡ LSD(1) means comparing between two main-plot treatment means averaged over all sub-ploteatments.
LSD(2) means comparing between two sub-plot treatment means averaged over all main-plot treatments.

The maximum value of total biomass belonged to the treatment of peanut intercrop with cassava with hedgerows, and minimum values were found in treatments of peanut - corn sequential and relay cropping without hedgerows. This indicated that cropping systems with hedgerows had an advantage in total biomass.

Contribution of crops to total biomass varied among treatments. The contributing percentage of peanut was from 40.5 to 58.8 % to total biomass. *T. candida* also contributed remarkably to total biomass with around 20 - 30 % total dry biomass (Appendix Table 11).

Total biomass was classified into two categories ie. economic yield (food and cash yield), and residue yield (Table 18). In general, dry food yield was from 10.6 - 17.0 % and cash yield (only peanut pod yield) was from 10.83 - 16.89 % in total biomass. However, in peanut - cassava intercropping, these changed to 44.8 % - 67.6 % in food yield and 4.5 % - 6.3 % in cash yield.

Residue yield was classified into two categories ie. leguminous and non-leguminous residue. the purpose of this classification is to evaluate quality of residue in terms of nutrients. Matthews et al, (1992) discussed that biomass quantity and quality together determined the contribution of nutrients to the soil. However, the net benefit to the system must take into account the fact that most of these nutrient come from the system itself. Leguminous residue is recognized as having higher nitrogen content. In the experiment, leguminous residue was effected separately by both factors of alley cropping and of cropping system ($P<0.01$). The higher in absolute value and relative ratio of legume residue in treatments resulted from the contribution of green matter of *T. candida*. This again indicated that hedgerows played a considerable role in improving soil productivity by providing a considerable amount of green manure to the soil. Similar result has been reported by Dau and Tien (1987) that cassava alley cropping with *T. candida* showed a high potential in upland as providing *in situ* green manure (10 ton/ha/year).

4.2.2 Soil conservation

4.2.2.1 Canopy cover in cropping systems

Upland farming in the Northern mountainous region of Vietnam is mostly on steep land and under climatic condition characterized by high peak rainfall. Soil erosion on the undulating topography has been serious. Impacts of raindrops on soil surface is the main cause of soil movement. The area and the structure of crop canopy covering on land surface are usually minimizing these forces.

Figure 3 and Appendix Table 2 and 3 show that rainfall in the area in recent years is concentrated during May to September (75 % total rainfall/year). A peak distribution of rainfall was in July to August. Particularly in 1992, rainfall distribution was earlier than that of the annual average. About 50.5 % of the rainfall occurred in June and July.

This time was also the stage of transition between first crops and second crops. First crops were being removed while second crops were still young, bare soil or less covered soil became vulnerable to raindrops impact.

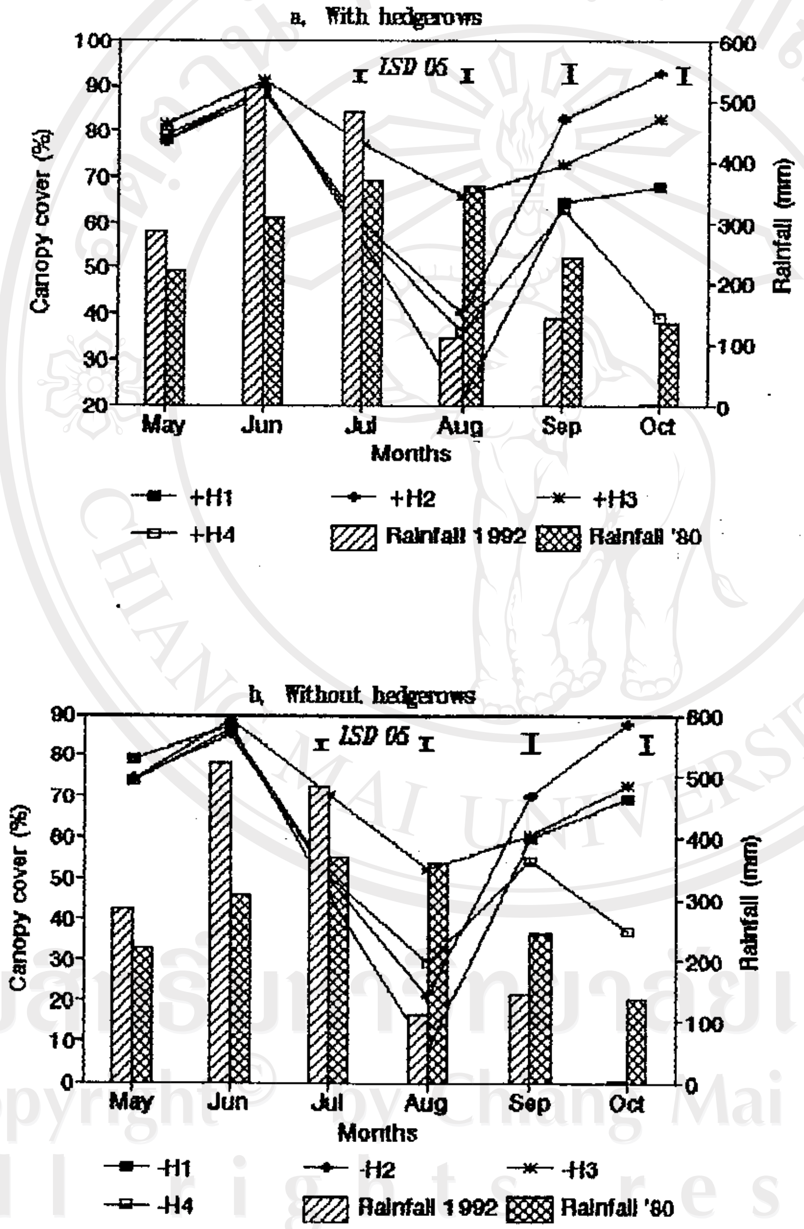

Figure 7: Percentage of canopy cover and rainfall of 1992 and 1980s at Thai Nguyen city

During May and June, crop canopy covered were as much as 73.83 - 91.43 %, with no significant differences among treatments (Figure 7). Peanut was an important contributor to this result (Appendix Table 12).

During late July, peanut was harvested, canopy cover reduced sharply, particularly in treatments without hedgerows and sequential cropping. In July, various cropping systems affected canopy cover (P<0.05). The highest canopy cover was observed in peanut - cassava intercropping and the lowest in peanut - corn sequential cropping. However, effects of hedgerows were not significant in canopy cover during July.

The lowest canopy cover was in August, particularly in treatment of peanut - corn sequential cropping. The value of canopy cover percentage in this cropping system was as small as 7.79 %. From July 23th to late August the land in this treatment was nearly bare. Both hedgerows and cropping systems affected on canopy cover significantly (P<0.05). Hedgerows played a considerable role in improving canopy cover at this time. Percentages of canopy cover in treatments with hedgerows were higher than those without hedgerows (Figure 8). For cropping patterns, there were three different groups of treatments in which the means of canopy cover percentages were significantly different from others. In descending order the values of canopy cover among the treatments were peanut - cassava intercropping, peanut - upland rice sequential cropping and peanut - corn relay cropping, followed by peanut - corn sequential cropping.

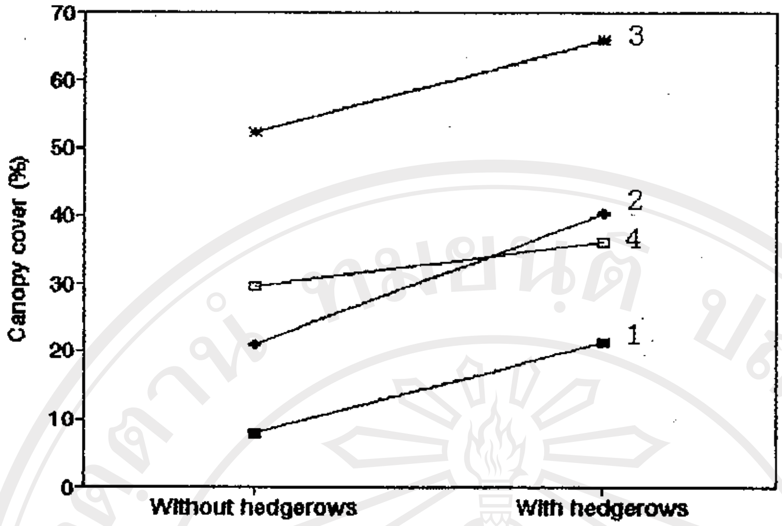

Figure 8: Interaction of alley cropping and cropping system factors effects on canopy cover during August

Cropping systems: 1 = peanut-corn sequential cropping;
2 = peanut-Upland rice relay cropping;
3 = peanut-cassava intercropping; and
4 = peanut-corn relay cropping.

In September, the effects of hedgerows disappeared while cropping system still affected canopy cover (P<0.05). The descendent order of canopy cover percentage among treatments were peanut-upland rice relay cropping, then peanut-cassava inter cropping, and last peanut-corn sequential and relay cropping.

Similarly in October, only cropping system treatments affected canopy cover (P<0.05). The descending order of canopy cover were peanut - upland rice relay cropping; peanut - cassava intercropping; peanut - corn sequential cropping ; and peanut - corn relay cropping.

4.2.2.2 Soil movement

Results indicated that average soil loss for all treatments was 108.15 ton/ha/year (Figure 9). The amount of cumulative soil loss was significantly different ($P<0.05$) among treatments (Table 19). However this was caused by the effects of the incorporation of alley cropping and cropping system factors to control soil loss (Figure 10).

Table 19: Soil movement and nutrient loss through soil loss

TRT	Bulk density (gram/cm^3)	Soil loss (cm)	Soil loss (ton/ha)	Nutrient loss (kg/ha) N	Nutrient loss (kg/ha) P_2O_5	Nutrient loss (kg/ha) K_2O
+H1	1.25	0.97	120.66	144.79	121.87	97.73
+H1	1.25	0.80	100.00	120.00	101.00	81.00
+H3	1.25	0.61	75.98	91.18	76.74	61.54
+H4	1.25	0.90	112.68	135.22	121.20	91.27
-H1	1.25	0.98	122.00	144.40	121.89	98.82
-H2	1.25	1.07	133.13	159.76	134.46	107.84
-H3	1.25	0.74	92.93	111.52	93.86	75.27
-H4	1.25	0.86	107.82	129.38	108.90	87.60
$\bar{X}$	1.25	0.87	108.15	129.78	109.99	87.60
Interaction			*			
CV (%)			21.56			
LSD .05(1)[1]			51.88	62.26	52.40	42.02
LSD .05(2)			9.91	11.89	10.01	8.03
LSD .05(3)			14.02	16.82	16.82	11.36
LSD .05(4)			39.65	47.58	47.58	32.12

Note: * shows significant interaction at 95 %

[1] The detailed explanation shows in Appendix Table 12.

The different response of treatments to soil movement was affected by both cropping systems and alley cropping. The lower soil loss in every treatment was found when it was incorporated with hedgerows than in without hedgerows. Peanut - cassava intercropping combined with hedgerows showed its high advantage in soil protection with the least soil loss for an average of 84.4 ton/ha/year (Figure 9).

The descendent order of soil loss in treatments were (-H2 = -H1 = +H1 = +H4) > +H2 > +H3; +H2 = -H4; -H4 > -H3; and -H3 = +H3 (where = indicates that there is no significant different among treatment).

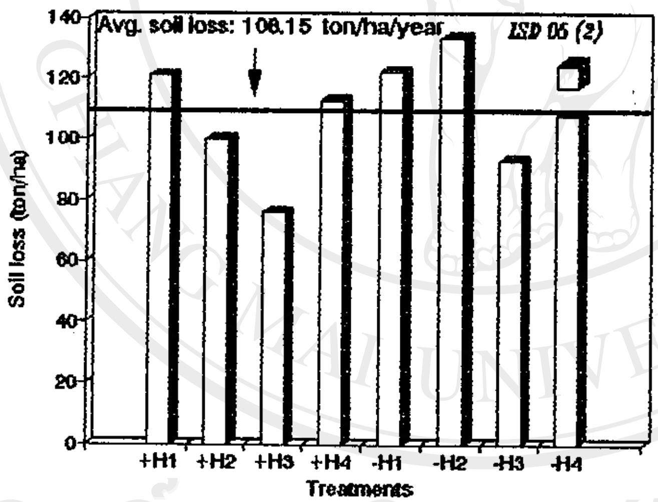

Figure 9 : Total soil loss over the year

There was negative relationship between canopy cover and soil loss (R^2 = 0.725) ($P<0.05$) (Figure 11). The consequence of soil loss was followed by nutrient loss shown in Table 19.

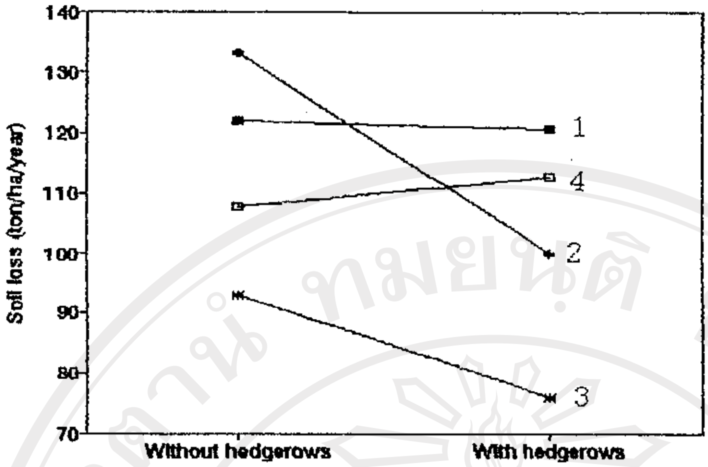

Figure 10: Interaction of alley cropping and cropping system factors effects on soil loss

Cropping systems: 1 = peanut-corn sequential cropping;
2 = peanut-Upland rice relay cropping;
3 = peanut-cassava intercropping; and
4 = peanut-corn relay cropping.

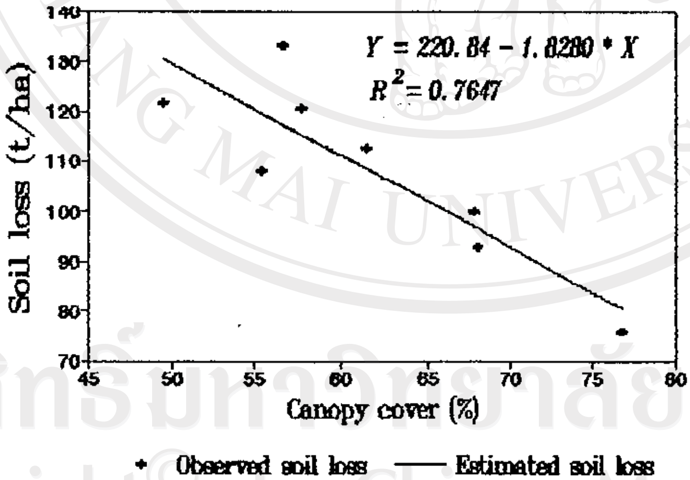

Figure 11: Relationship between soil loss and percentage of canopy cover

4.2.2.3 Soil nutrient change

The results of soil chemical analysis revealed the differences in concentrations of nutrients in the soil before and after the experiment (Table 20). However, the concentration of nutrients varied in different ways.

Table 20: Soil nutrient changes

TRT	pH	OM (%)	N (%)	P_2O_5(ppm)	K_2O(ppm)
A. Soil sample before setting the experiment					
+H1..-H4	4.5	1.893	0.085	790	1200
B. Soil sample after harvesting crops					
+H1	4.6	2.630	0.122	786.67	816.67
+H2	4.6	2.490	0.105	720.00	923.33
+H3	4.8	2.457	0.124	683.33	816.67
+H4	4.6	2.623	0.124	740.00	783.33
-H1	4.7	2.397	0.124	713.33	883.33
-H2	4.7	2.250	0.126	756.67	766.67
-H3	4.8	2.583	0.117	803.33	700.00
-H4	4.8	2.680	0.117	856.67	766.67
$\bar{X}$	4.7	2.514	0.120	757.50	807.08
Interaction	ns	ns	ns	ns	ns
CV (%)	6.2	19.340	20.000	13.35	17.65
LSD .05	ns	ns	ns	ns	ns
C. Difference between before and after the experiment was carried out					
+H1..-H4	0.2	0.621	0.035	-32.50	-392.92

Positive change were in pH, nitrogen, and particularly organic matter (increased by 0.621 %), while negative changes were found in potassium and phosphorus. Particularly, the average potassium decreased at the amount of 392.9 ppm. The Potash and Phosphate Institute of Canada (1989) stated that leaching loss of potassium was a major concern under frequent intense rainfall condition in well drained soil of the humid tropic. However, no significant difference of nutrient changes was found among treatments.

4.2.2.4 Nutrient budget

Estimated nutrient budget among treatments in a year is shown in Table 21. Nitrogen increased while phosphorus and particularly potassium decreased. Reasons for these differences could be explained by many factors such as the fixing nitrogen from the air by leguminous crops (People and Herridge, 1990), leaching (the Potash and Phosphate Institute of Canada, 1989), nutrient loss by run off and soil loss (Kang et al., 1989) etc. Average loss through economic products and soil loss were 185.0 kg N; 103.7 kg P_2O_5; and 97.0 kg K_2O/ha/year , while the loss of N, P_2O_5 and K_2O through soil loss were 70.1; 92.7 and 90.3 % respectively. Ngambeki (1985) also reported the increase of nitrogen which results a substantial saving in the use of N fertilizer when alley cropping *L. leacaena* with corn.

Table 21: Nutrient partial budget

(kg/ha)

Items	+H1	+H2	+H3	+H4	-H1	-H2	-H3	-H4
1. Input								
- N	2189.10	2189.64	2188.23	2189.10	2198.99	2189.64	2188.88	2189.99
- P_2O_5	2035.47	2530.67	2035.52	5035.47	2035.57	2035.67	2035.62	2035.57
- K_2O	3040.67	3040.87	3041.40	3040.67	3040.82	3040.87	3041.88	3040.82
2. Output								
- N	3243.78	3240.91	3202.10	3231.38	3236.72	3252.06	3194.51	3233.69
- P_2O_5	2007.00	2004.09	1983.55	2005.16	2005.50	2004.29	1982.36	2004.28
- K_2O	2166.24	2162.64	2139.12	2163.33	2164.97	2164.12	2138.30	2163.55
3. Differences between output and input nutrients								
- N	1054.68	1051.27	1013.87	1342.28	1046.73	1062.42	1005.63	1043.70
- P_2O_5	-28.47	-31.58	-51.97	-30.31	-30.07	-31.38	-53.26	-31.29
- K_2O	-874.43	-878.23	-902.28	-877.34	-875.85	-876.75	-903.38	-877.27
4. Nutrient moving directions								
4.1 In the soil*								
- N	3076.63	3090.80	3052.32	3068.11	3067.15	3094.33	3039.55	3068.16
- P_2O_5	1908.66	1911.22	1907.60	1907.76	1906.67	1910.70	1905.42	1906.46
- K_2O	2040.24	2041.21	2042.20	2038.22	2038.47	2041.53	2040.32	2037.99
4.2 Nutrient loss in economic products and soil loss								
- N	167.15	150.12	149.78	163.28	169.57	157.73	155.01	165.52
- P_2O_5	97.34	92.87	75.95	97.40	98.83	93.59	76.94	97.83
- K_2O	126.00	121.42	96.92	125.11	126.50	122.60	97.98	125.56
4.2.1 Percentage of nutrient loss in economic products (%)								
- N	28.84	20.77	42.20	27.15	29.86	24.59	44.15	28.14
- P_2O_5	8.55	33.16	13.82	7.67	9.00	3.91	14.92	8.07
- K_2O	7.44	3.96	12.42	6.79	7.81	4.87	13.36	7.12
4.2.2 Percentage of nutrient loss in soil loss (%)								
- N	71.16	79.23	57.80	72.85	70.14	75.41	55.85	71.86
- P_2O_5	91.45	96.84	86.18	92.33	91.00	96.09	85.08	91.93
- K_2O	92.56	96.04	87.58	93.21	92.19	95.13	86.41	92.88

* Soil and residues contained nutrients

4.2.3 Economic evaluation

An economic assessment of cropping systems was undertaken to determine the advantage as well as disadvantages of cropping patterns.

For total variable costs, labor costs were by far the largest. The highest labor cost (63.5 %) was associated with peanut - corn sequential cropping without hedgerows (-H1) and the lowest labor cost (57.1 %) was in the treatment of peanut - cassava intercropping with hedgerows (+H3) (Appendix Table 13a, 13b).

However, Treatments of Peanut - cassava intercropping got the highest return (average 7,304,000 dong/ha/year, equivalent to US$ 695.7) (Table 22). There were no significant differences in return and gross margin among treatments.

Analysis of economic efficiency by using the Return to Material Cost (RTMC) and Return to Labor Cost (RTLC) showed that peanut - cassava intercropping with hedgerow gave the highest efficiency of 3.02 dong/dong and 17,142 dong/manday respectively.

Table 22: Economic estimation of different treatments (per hectare)

TRT	Return (1000d*)	Variable cost (1000d)	Gross margin (1000d)	RTMC (d/d)	RTLC (d)
+H1	7183.04	5257.25	1925.79	2.10	12388
+H2	-	-	-	-	-
+H3	7304.64	4223.83	3080.81	3.02	17142
+H4	6911.79	5133.25	1778.54	2.01	12225
-H1	7183.41	6028.75	1154.66	1.61	10229
-H2	-	-	-	-	-
-H3	7304.64	4662.58	2642.06	2.63	14953
-H4	6911.79	5864.75	1047.04	1.61	10499
$\bar{X}$	7133.22	5195.00	1938.15	2.16	12906
Interaction	ns				
CV(%)	14.53				
LSD .05	ns				
LSD .01	ns				

* d is dong (Vietnamese currency)