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Intensification of Shifting Cultivation by the Use of Viny Legumes in Northern Thailand

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Abstract

The present study describes a complex multiple cropping system of six crops which has evolved in a Lisu village in Chiang Mai during the last 17 years. The system involves relay planting of three viny legumes [cowpea (*Vigna unguiculata*), rice bean (*Vigna umbellata*) and lablab bean (*Lablab purpureus*)] after inter-cropping of maize and wax gourd (*Benincasa hispida*) or pumpkin (*Cucurbita moschata*). The relay-cropping of the three viny legumes could be considered as a locally evolved type of accelerated seasonal fallow management aimed at soil fertility replenishment and income generation in an intensified shifting cultivation system. The Lisu farmers adopted this system because of their prior experiences on market economy and their knowledge of multiple cropping technology through previous maize-opium based farming, as well as because of the availability of a large area of fertile land to sustain intensive cultivation without external inputs. The ability of the multiple cropping system to generate acceptable income and the availability of transportation for the products were also positive factors favoring its adoption. On the other hand, its lower profitability than competitive cropping systems, such as vegetable seed production, and its requirement for good transportation, large farm size and fertile soils constrained its expansion. The present study also revealed that external factors of economy and technology development are crucial in determining if environmentally beneficial cropping systems will continue in use in the long-term or be replaced with less environmentally friendly agricultural practices.

Keywords: viny legumes, rice bean, lablab bean, cowpea, accelerated fallow, relay cropping, shifting cultivation, Northern Thailand

I Introduction

Increase in population and, consequently, growing pressure on land have resulted in a shortening of the fallow period of shifting cultivation in Northern Thailand. This may cause decline in agricultural productivity and increased vulnerability to environment hazards. One measure to cope with a shorter fallow period is to improve fallow management. Shifting cul-

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tivators also face changing circumstances such as improvement of transportation and communication, and spread of the market economy. Increased extension services by the government sector and NGOs help by introducing new crops, cropping patterns and agricultural inputs even to remote areas. These new circumstances and technologies, in addition to indigenous knowledge, may help to mediate the pressure on land and also to upgrade the livelihood of shifting cultivators.

A complex multiple cropping system of relay growing of three viny legumes [cowpea, (*Vigna unguiculata*), rice bean (*Vigna umbellata*) and lablab bean (*Lablab purpureus*)] after inter-cropping of maize and wax gourd (*Benincasa hispida*) or pumpkin (*Cucurbita moschata*) has evolved over the past two decades ago in a Lisu village in Northern Thailand. The system can be considered as a type of intensified shifting cultivation by means of introducing commercial crops and improving fallow management. The present study describes the process of innovation, examines the functions and limitations of this intensified shifting cultivation, and discusses the applicability of intensified shifting cultivation to other areas in the mountainous regions of Mainland Southeast Asia.

II Study Area and Field Survey

Huai Nam Rin, Huai Go and Mae Pam Norg villages in Chiang Dao district, Chiang Mai, were selected as the sites for the present study. Mae Pam Norg and Huai Go villages are 11 km apart, and were established some 50 and 40 years ago by Northern Thai and Karen people, respectively. Later, Akha, Hmong and Lisu migrated into these villages. Huai Nam Rin village was established in 1978 in a relatively undisturbed forest between the two villages by Lisu people because the two old villages were then already too crowded. The main characteristics of the three villages are summarized in Table 1.

The climate is tropical monsoon with mean annual rainfall of 1,250 mm and a pronounced dry season during the period from November to April. The elevation of the area is about 500 m above mean sea level. The natural vegetation was mixed deciduous forests. These villages are located on a long narrow foothill between a limestone mountain on one side and a shale/schist mountain on the other side. The cultivated lands have soils derived from limestone and are relatively flat compared to other shifting cultivation areas in Northern Thailand [Kunstadter and Chapman 1978]. All fields are located inside legally declared national forest reserve land.

At present, maize is the major crop in the three villages. The old villages also have lowland paddy fields. Cultivation of upland rice has already disappeared in the three villages, though it is still continued, particularly as a ritual crop, in nearby villages.

The first field survey was done in April 1997. We conducted participatory rural appraisal (PRA) exercises two times in Huai Nam Rin village and group interviews with farmers in Huai Go and Mae Pam Norg villages. We re-visited the villages in February 2002 and con-

Table 1　Some Important Parameters of the Three Villages

	Huai Nam Rin	Huai Go	Mae Pam Norg
Ethnic Groups	Lisu	Karen, Akha, Lisu	Thai, Hmong, Lahu
No. of households	70	98	62
Years of establishment	1978	Some 50 years ago	Some 40 years ago
Road assessment	Unpaved roads Difficult to access in the rainy season	Unpaved roads Difficult to access in the rainy season	Paved roads All year round accessible
Legal landuse rights	None	None	Some
Distance from Huai Nam Rin	—	7 km	4 km
Main soil types	Clayey Oxic Paleustuls with very good soil structure		
Slopes of cultivated areas	5–20%	5–20%	5–20%
Elevations	460–500 m	560–600 m	460–500 m
Average land holding per household	4 ha	3 ha	2 ha
Off-farm employment	None	Yes	Yes
Lowland rice fields	None	Yes	Yes
Upland rice cultivation	None	Yes	None
Farmers who practiced the system	Almost all	More than half	About a quarter

ducted group interviews with farmers. We also collected soil samples and analyzed their physical and chemical properties to evaluate changes in soil fertility.

III Shifting Cultivation Systems before the Innovation

Conventional shifting cultivation systems in Northern Thailand vary among ethnic groups. In general, they are upland rice and maize-based mixed cropping under the rainfed condition. Other vegetable crops such as cucumber (*Cucumis sativus*), wax gourd (*Benincasa hispida*), pumpkin (*Cucurbita moschata*), angled luffa (*Luffa acutangula*), sponge gourd (*Luffa cylidrica*), chili pepper, etc. were inter-cropped in upland rice and maize fields. The Karen and Lua adopted a “short cultivation–long fallow system” because they were permanently settled in valleys and have been also engaged in lowland paddy cultivation and orchard growing. Being relative newcomers to Northern Thailand, Hmong, Lisu and Akha had to settle on relatively higher and steeper terrain. They traditionally had no lowland paddy and orchards, and depended fully on shifting cultivation. The major cash crop was opium. They grew opium by relay-cropping with maize, planting opium one month before maize harvest [Keen 1978]. The whole community moved to a new settlement when the surrounding cultivated lands were exhausted. Their system was described as “long cultivation–very long fallow system” or “pioneer shifting agriculture” [Kunstadter and Chapman 1978].

In the study area, maize replaced upland rice as the core crop of shifting cultivation several decades ago. Farmers sell maize and buy rice for their home consumption. About the half of the farmers in Huai Go village still grew upland rice in the late 1990s as a ritual crop, but no farmers in Huai Nam Rin and Mae Pam Norg villages grow upland rice any more. This indicates that farmers of the study area have adopted a market-oriented strategy of farm management even before the innovation of shifting cultivation system.

The Hmong, Akha and Lisu who migrated into the study area could not grow opium in their new lands because the climate was too warm due to the low elevation. Instead, they grew many kinds of fruit trees, mango in particular, as cash crops. Farmers reported that strict reforestation programs accerelated the creation of mango plantations, even in shifting cultivation fields far away from the settlements, because planting fruit trees was a way for them to make their land claims more secure, as Pahlman [1992] reported.

Farmers identified marketing of the products, weeds, reforestation program, soil quality declining, insects and diseases, and drought as the major farming problems. Soil erosion was not recognized as a severe problem for them.

IV Innovative Shifting Cultivation

IV–1 *Introduction of Viny Legumes*

When the farmers settled down in the present locations, they did not know rice bean and cowpea. They knew lablab bean but did not widely grow it. The innovation of relay-cropping of maize and viny legumes has been evolved at Huai Nam Rin village by means of upscaling of indigenous technology and application of external knowledge since 1980, two years after the establishment of the settlement.

Relay-cropping of lablab bean with maize started in 1980. A woman farmer found some seeds of lablab bean in a sack of unhusked rice which she bought from another village. As she opened the sack in maize field, she planted the seeds there. Relay-cropping was an old practice for them because they were accustomed to grow opium with maize before. So the practice of growing lablab bean in maize field was quite natural for them.

In 1982, two years later, a Lisu farmer who had migrated from Kampaeng Phet started to grow rice bean. He obtained the seeds of rice bean as well as planting recommendations from an officer of Department of Land Development at Kampaeng Phet.

Cowpea[1)] was first introduced to the study area by one of the authors. This was the native climbing type, but was not accepted by farmers due to low yields. Then, the bush type of cowpea was introduced in 1993. The seeds of cowpea were accidentally left on a truck of a middleman, and farmers freely got them. This type of cowpea was already grown as a second crop in Prao district, approximately 20 km away.

IV–2 *Cropping Calendar and Technology*

A complex cropping system using viny legumes was established after many trials and errors in Huai Nam Rin and two neighboring villages. The cropping calendar of this system is sum-

1) Both rice bean and cowpea (bush type) were originally developed at the International Institute of Tropical Agriculture (IITA) (personal communication with Prof. A. Thirathon, Department of Agronomy, Mae Jo University).

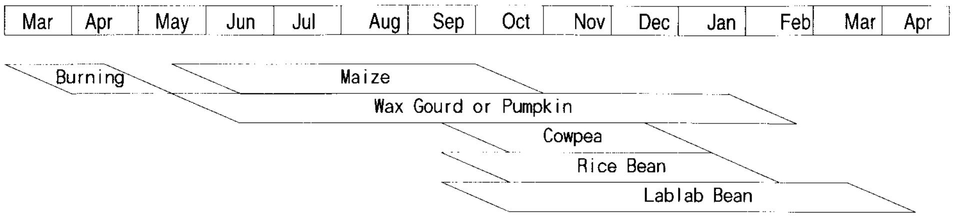

Fig. 1　Cropping Calendar of the Complex Innovated Multiple Cropping System

marized in Fig. 1. The main element of the system is the inter-cropping of maize with wax gourd or pumpkin, with the relay-cropping of the three viny legumes as a subsidiary element. This intensive cropping system is used in fields where there are no trees or small fruit trees, and it is not applicable in fields with mature fruit trees.

In March and April, fields are first weeded with hoes and the crop and weed residues piled and burned. Farmers reported that the functions of burning are to suppress weed growth and to mitigate pests and diseases. Delay in the harvest of previous lablab bean crop causes delay in the field preparation, which reduces the effects of burning. Use of farm tractors is prohibited in the study area by the Forestry Department as a way to keep farmers from expanding the cultivated land, although deforestation is still going on and the cultivated land is actually expanding.

In May, maize and wax gourd or pumpkin are sown together. They are inter-cropped by simply mixing the seeds of both crops at the ratio of 20 to 40 : 1 for maize and wax gourd or pumpkin seeds. Land is not plowed before sowing and the seeds are put in holes which are manually dug by spade. Plant spacing of maize is approximately 70×50 cm with two plants per hill, while the best spacing of wax gourd is 2×2 m. Wax gourd is thinned if the plants grow too closely. The major variety of maize is Suwan 5, an open-pollinating variety.

Chemical fertilizer is seldom used. Weeding was formally totally done by hand, but use of herbicides has recently been spreading due to lack of labor. Labor shortage also provides farmers with the incentive to introduce farm machinery into their cultivation, and actually some farmers have started to use power tillers.

Cowpea, rice bean and lablab bean are separately sown in maize fields one month before the harvest of maize. Before sowing the legumes, weeding is done once and the vines of wax gourd or pumpkin are pulled out and piled in circular areas of 1–1.5 m far from their hills in order to open space for the legumes to grow. Farmers said that this practice did not harm the growth of wax gourd but stimulated the sprouting of new shoots, which resulted in higher yields. The legumes are planted in between the rows of maize. The plant spacing is 70× 50 cm for rice bean and lablab bean and 70×30 cm for cowpea. The labor availability of each farmer determines what proportion of the maize field is relay-cropped, but in most cases relay-cropping is practiced not in the whole area. Sowing of the legumes could be extended until the end of October if there is enough rain in the second half of the month.

The harvest of the six crops is distributed from October to April. In October, maize is harvested, followed by cowpea in December and January, wax gourd, pumpkin and rice bean in January and February, and lablab bean in March and April. Wax gourd and pumpkin fruits which lay on the ground are easily picked after the harvest of cowpea and rice bean. On the other hand, harvesting of wax gourd in lablab bean fields is difficult since the fruits are covered with bean canopies and fully grown green pods of lablab bean contains certain oil with unpleasant smell that caused skin irritation.

Lablab bean is not grown in fields with mango trees because the plants fully cover the ground during the whole dry season. This vegetation provides habitats for rats that may destroy the trees. The high risk for fire that could destroy the young trees is another reason.

IV–3 *Impact on Soil Properties*

In order to examine the impact of the above-mentioned relay cropping on soil properties selected indicators of soil property such as pH, organic matter content and available phosphate, in addition to yields of maize, were measured in four pairs of cultivated fields with and without relay cropping and with each pair having been under continuous cultivation for different lengths of time, and three plots of disturbed forests (with burned undergrowth plants) near the cultivated fields. The available phosphate was measured by the Bray II method. The yields of maize were calculated by dividing the production obtained from the farmers by the field area measures by the global positioning system (GPS) device. The results are shown in Table 2.

Soil organic matter shows a clear decreasing trend corresponding to the length of cultivation period for both cases with and without relay cropping. Available phosphate also decreases according to the length of continuous cropping, but this trend was not clear in case without relay cropping. pH shows neither increasing nor decreasing trends in both cases. Compared to non relay-cropped fields, relay-cropped fields always show higher organic matter content. Available phosphate of relay-cropped fields is higher until five years of continuous cropping and smaller afterward than that of non relay-cropped. These results suggest that relay cropping of viny legumes facilitated the delay in the depletion of soil organic matter and available phosphate, but its effect on available phosphate disappear in

Table 2 Changes in Soil Property by Cropping Pattern and Length of Continuous Cropping

Length of Continuous Cropping	pH		Organic Matter		Available Phosphate		Maize Yields	
	Relay	Non Relay	Relay	Non Relay	Relay	Non Relay	Relay	Non Relay
No cultivation (forest)	6.3		6.10		94		—	
3 to 4 years	6.3	6.2	5.61	4.42	119	97	3.26	1.57
5 years	6.1	6.7	5.29	5.43	96	70	4.71	3.55
10 to 11 years	6.2	6.4	4.42	3.23	70	83	3.00	2.12
15 to 17 years	6.6	6.8	3.93	2.92	57	87	3.55	2.62
Average	6.3	6.5	4.81	4.00	86	84	3.63	2.47

case of long continuous cultivation.

The overall average yield of maize is 3.05 t/ha. This is almost 50% higher than the national average, reflecting the presence of limestone-originated fertile soil in the study area. The average yield of maize with legume relay-cropping was 3.63 t/ha, which is obviously better than that without relay-cropping, 2.47 t/ha. Higher mineralization of nutrients, especially nitrogen, due to higher organic matter contents is thought to be the dominant reason for the better performance of maize in the relay-cropping system. Farmers pointed out the relationship between maize yields and the family labor supply. The households who adopt the relay cropping system usually have sufficient family labor, so that they also input enough labor for weeding. This causes higher yields of maize.

IV–4 *Farm Economy*

The income obtained from the innovative cropping system in Huai Nam Rin village was roughly estimated based on information obtained through field survey. The total production of the six crops in the year 1996/97 was estimated by counting the number of different sizes of trucks that transported the products. The unit price of the products varied by season, though, so we used the average prices. It must be noted that middlemen usually offered a better price to them than to their neighboring villages because Huai Nam Rin village produced much bigger volume of products. This is one of the advantages for this village to promote this cropping system. The results of the estimation are summarized in Table 3.

The biggest income comes from the sale of maize, which account for about half of the gross income. The three viny legumes provide in total about 40%. This clearly indicates the economic importance of these crops. The average gross income in the village was US $2,700/household. Some farmers have additional income from the sale of fruits. Most of the farmers were satisfied with this income status which was comparable to the income which they had earned from opium.

IV–5 *Improvement of the Productivity of the System*

Farmers of Huai Nam Rin village recognized the significant impact of modern technology such as hybrid varieties of maize, tillage using farm tractors and chemical fertilizers on the

Table 3 Production and Cash Incomes of the Innovative Cropping System in Huai Nam Rin Village (1996/97)

Crops	Production (t)	Unit Price (US$/t)	Gross Income (US$)
Village total			
Maize	700	135	94,500
Cowpea	80	425	34,000
Rice bean	100	290	29,000
Lablab bean	80	230	18,400
Wax gourd	220	58	12,760
Pumpkin	15	192	2,880
Average per household			2,736

productivity of the system when we surveyed in 1997.

In 1996 some farmers started using a hybrid variety instead of an open-pollinating type of high-yielding variety, Suwan 5, which was widely used before, and experienced 50% higher yields. Then in 1997, almost all households in the village adopted the hybrid maize variety, even though the cost of seeds was rather expensive, US$5 per kg.

We also proposed earlier relay-cropping of legumes as a measure to improve the productivity of the system. A research study done in Chiang Mai showed that relay growing of cowpea and lablab bean with maize did not affect maize yields if cowpea and lablab bean are sown 60 to 100 days after the sowing of maize [Insomphun and Kanachareonpong 1991]. This research also showed that legume yields increased with earlier planting. Yields of cowpea and lablab bean sown 60 days after maize planting were 14 and 10 folds higher than those sown 100 days after maize planting, respectively. Some farmers seemed to be interested in this proposal and actually tried earlier planting of legumes in small patches of their fields, but the results are not known.

IV–6 *Collapse of the System*

In 2000 and 2001, the prices of the three viny legumes dramatically dropped. The prices of rice bean and cowpea have decreased to about half that of the earlier years, while the price of lablab bean has reduced to less than a quarter. These changes in prices pushed farmers to replace the viny crops with groundnut, which had a good price at that time. In the 2002 cropping season, rice bean and cowpea have completely lost their places in the system, although some farmers continue to grow lablab bean in 2002 as a fallow crop in summer.

Changes in crops from viny legumes to groundnut caused serious problems in the form of thick weed growth and hard soil. These must be partly due to long and continuous cultivation with no tillage.

Hard soil is a problem at the time of harvesting groundnut, which must be pulled out from the ground. The Forest Department, therefore, relaxed enforcement of the regulation against using tractors. Some farmers actually started using them for plowing fields before cropping, but this practice has only spread to a limited extent.

Use of herbicide is spreading. The number of herbicide users has increased and types of herbicides changed. Herbicide previously used in maize fields was Gramoxone, a contact non-selective herbicide which destroys only parts of wax gourd and pumpkin plants that directly contact with the herbicide. Herbicide presently used is Atrazine, a selective systemic herbicide killing all broad leaf weeds. Although inter-cropping of wax gourd and pumpkin decreased, their cultivation still continue because markets are available for these crops.

When we talked with farmers in 1997, some farmers mentioned that most of their fields would be full with fruit trees, mango in particular, within 10 years. This idea expressed their perspective that they can earn more income with less labor input from orchards than from the relay cropping system. Actually some maize fields with relay cropping of viny legumes have been replaced by mango plantations since then, but the expansion of orchard was not as much as it was expected in 1997. The sharp drop of mango price in the past several years could be a primary reason.

V Discussion

V–1 *Factors that Contributed to the Innovation*

Several factors can be raised as possible driving forces to establish the innovative system.

1) The Needs for New Cash Crops

Since 1985, cultivation of opium has been strictly controlled by the government by means of cutting all opium crops found in fields [Seetisarn 1995]. This measure forced opium growers to seek for new cash crops, and some people moved and established new settlements in order to grow different kinds of cash crops which can substitute for opium. Migration of the Lisu families, former opium growers, to Huai Nam Rin village during the period between 1986 and 1990 is a part of this movement. They had to establish a new cropping system including cash crops without opium in the new land.

2) Farmers' Experience with Multiple Cropping

Farmers had previous experience of a complex cropping system, inter-cropping of maize and vegetables and relay-cropping of opium. This was a part of the traditional farming system of opium growers [Keen 1978]. Idea from and techniques of the traditional farming must have helped in establishing the innovative system.

3) Availability of Land to Generate Acceptable Income from the Innovation

The average farm size of Huai Nam Rin village is 4 ha, while it is 3 ha in Huai Go and 2 ha in Mae Pam Norg villages (Table 1). Thus, farmers in Huai Nam Rin village possessed comparatively big farms with sufficient land to generate an acceptable income from the system. The farmers adopting the system in Huai Go and Mae Pam Norg villages also hold bigger farm lands than the non-adopters. Small land holders in Mae Pam Norg village were engaged in contract farming to produce seeds of flowers and vegetables because it is labor-intensive and they could earn higher income per unit area. In addition, the village is located along a paved road and most of the farmlands there were accessible by pickup trucks even in the rainy season, which is a prerequisite condition of contract farming for seed production. The non-adopters who have smaller lands than contract farmers had to earn money from off-farm jobs.

4) The Need for an Efficient Weed Control System

The prohibition of the use of farm tractors in the villages has compelled the farmers to adopt other efficient weed control systems instead of annual plowing. The fast growing vegetables such as wax gourd and pumpkin have provided farmers with better weed control during their early growing stage. These crops also were additional income sources because farmers sell them to a local military camp. The dual functions of growing wax gourd and pumpkin accelerated the expansion of their cultivation. At present, wax gourd is collected by local middlemen and sent to food factories in Bangkok. Farmers also recognize the effectiveness of relay-cropping of the three viny legumes on weed control.

5) High Ability of Limestone-based Soils to Sustain Cultivation

Before the Lisu families migrated, they carefully selected lands for resettlement. They selected the present Huai Nam Rin village because the area was covered with dense mixed deciduous forest with limestone-originated soils, and they judged, based on their experiences, the land could sustain intensive and continuous cultivation for several years. Such knowledge of shifting cultivators in Thailand is also reported by Keen [1978] and Kunstadter and Chapman [1978]. These soils have high pH and calcium content, which are essential for efficient nitrogen fixation of Rhizobium and growing of most legumes.

6) Availability of Transportation for the Products

Huai Nam Rin village was just four kilometers away from a paved road. The village was easily accessible by an earth road during the dry season.

V–2 *Constraints on Expanding the Innovative System*

The innovative system spread in the study area, but did not cover the whole study area. Almost all 70 households in Huai Nam Rin village have practiced the system but the share of adopters of the system in the two neighboring villages varied from a quarter to a half of the village households. This type of cropping system is seldom observed in nearby areas. The constraints for expanding the system are thought to be as follows.

1) Market for the Products

Although relay-cropping of legumes provides better weed control and soil fertility improvement, farmers said that they would only practice this system in small areas just enough for household consumption if they could not sell their products. The quick change of crops from viny legumes to groundnut when the prices of legumes sharply dropped reflected this idea. These clearly indicate that the farmers' decision for cropping system is primarily based on the profitability of the system. This is the biggest constraint for the expansion of relay-cropping of legumes.

2) Transportation of the Products

This innovative system needs good transportation at least in the dry season. In the case of Huai Nam Rin village in 1996/97 cropping year, big trucks were needed to transport the 1,195 tons of products from the village center (Table 3), and pickup trucks for collecting the products from the fields to the village center. This suggests that this system could not be adopted in remote villages inaccessible by trucks and pickup trucks.

3) Big Farm Lands

One major reason why there were non-adopters of relay-cropping in Mae Pam Norg village was the insufficient farm size. Land holding was not big enough to adopt the innovative system to generate an acceptable level of cash income. A non-adopter in Mae Pam Norg village figured out that the maximum gross income earned from the system was US$700 per ha. Thus a household should have three to four hectares of farm land to earn an acceptable income. Being contract farmers for vegetable and flower seed production could enable them to earn about US$1,900 per ha. Farmers possessing only one to two hectares of farm, therefore, prefer contract farming to the innovative system, if they have a good road access.

4) Soil Fertility

The innovative system is a form of semi-permanent intensive cultivation. The use of chemical fertilizer is still not popular so that production depends completely on the mining of soil nutrients. The results of soil analyses indicate that soils of Huai Nam Rin village originally contained very high levels of phosphorous and could, therefore, maintain the high nutrient availability even after 17 years of cultivation (Table 2). This suggests that upgrading of soil properties is a prerequisite for applying the innovative system to poor soil areas.

VI Conclusions

The process of creation and collapse of a complex multiple cropping system at a Lisu village in Northern Thailand was studied. The following factors were considered as mechanisms that contributed to the system's innovation by the farmers: their prior experiences with the market economy and multiple cropping technology through previous maize-opium based farming; availability of big farms with fertile land to sustain intensive cultivation without external input and to generate acceptable income; availability of transportation for the products. The prohibition of using of farm tractors in national forest reserve, which forced the farmers to attempt other efficient weed control systems, could be considered as another mechanism.

Although relay-cropping of viny legumes is, agronomically speaking, an excellent cropping system that helps to control weeds and improve soil fertility, this system does not cover the whole study area. Constraints on the expansion of the system are: lower profitability than competitive cropping system such as seed production; bad transportation conditions; small farm size and less fertile soils.

Sustainability of the cropping system is primarily controlled by economic, ecological and technical factors. This case study, however, clearly showed the importance of the economic factor. The determinant factor of crop selection, a major component of the system, was the changes in crop prices. When prices of the three legumes dropped, farmers quickly replaced them with other crops, such as groundnut, which were more profitable. Nevertheless groundnut is less advantageous than viny legumes from the ecological viewpoint in terms of providing soil cover.

Another factor influencing the long-term dynamics of the system is the main stream agricultural technology such as the use of farm tractor and herbicides. These technologies respond to the need of farmers to manage land and labor more efficiently. What is going on in the mountainous region in Northern Thailand is, unfortunately, that these technologies lead to adoption of agricultural practices that are less environmentally friendly than the original ones. It is urgently required to utilize main stream agricultural technology in ways that lead to better management of mountain agriculture.

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