The Use of Green Manure/Cover Crops for Relay Cropping in Northern Thailand

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Introduction

During the late rainy season, the permanent hill fields that surround a cluster of hilltribe villages in the Chiang Dao district of northern Thailand radiate various hues of green. These verdant fields, belonging to ethnic Lisu, Lahu, Akha, Palaung and Karen farmers, are covered in a patchwork of green manure/cover crops (gm/ccs) that include rice bean (*Vigna umbellata*), cowpea/black bean (*Vigna unguiculata*), lablab bean (*Lablab purpureus*), peanut (*Arachis hypogaea*) and jack bean (*Canavalia ensiformis*).


Northern Thai gm/cc production

The extensive plantings of gm/ccs are part of a legume-maize relay cropping system that local farmers developed in the early 1980s. **Relay cropping** is a type of intercropping with two or more crops grown simultaneously during part of their life cycles. The second crop is often planted after the first crop has reached its reproductive phase, but before it is ready to harvest (Van Keer, *et al*.).

Through the years, this system of relay cropping gm/ccs has caught the attention of outside agriculture development agencies and farmers. The ECHO Asia Impact Center often takes visitors to meet the hilltribe farmers and observe their approach of growing gm/ccs. This article will describe these farmers' efforts, weigh strengths and weaknesses of the system and explore opportunities for others to possibly adopt and adapt similar approaches elsewhere.

Farming transitions in the Sri Lanna Park

The complex of hilltribe villages where relay cropped gm/ccs are grown is located within the borders of the Sri Lanna National Park. Each community was established before the announcement of the reserve in 1989. Previously, the hilltribe farmers practiced shifting cultivation, primarily of upland rice. The rice was grown in association with other field crops that included sesame, sunflower, chili pepper, crawling legume varieties, pigeon pea, sorghum and various species of cucurbits.

Traditionally, hill fields are returned to a forest fallow for at least a few years to allow the soil to recover fertility. Once soil fertility is adequately restored, another cycle of field cropping takes place. Although park authorities currently allow an informal degree of land tenure for farm families living within Sri Lanna, agricultural activity is restricted to fields that have been cleared for decades. The farmers of Sri Lanna are now forbidden from clearing land for rotational farming.

The soil within the permanent hill fields (elevation 450-600 m asl) is of two main types: productive limestone soils and easily degraded quartz schist soils. Although some fields are relatively level, most cultivated areas are quite steep.

Based on informal community land management systems, families lay claim to undeeded tracts of land; most household acreage is less than 1-2 hectares (1 ha equals 6.25 *rai*; the standard land unit in Thailand). With such limited access to farmland and with shifting cultivation prohibited, traditional forest fallows (typically 3 to 10 years) are no longer possible.

The shift to relay cropping began in the early 1980s when local farmers began growing lablab bean in corn fields using seed found in unhusked rice brought in from another village. Two years later, they began growing rice bean from seed obtained from the Land Development Department (LDD). During the early 1990s, a productive bush type of cowpea (black bean) was introduced by a market middleman, followed a few years later by peanut. Finally, jack bean was introduced around the mid 2000s (though overall acreage remains limited).

Gm/ccs for accelerated seasonal fallow

The widespread system of relay cropping corn and legumes over the Sri Lanna village cluster has been described by Somchai and Prinz as being an **accelerated seasonal fallow management system**. By establishing gm/ccs within a mature stand of corn (sowing approximately one month before the corn is harvested), a significant amount of nitrogen fixation and biomass production takes place between corn crops. Therefore, the aims of a natural fallow (i.e. improved soil condition and better crop production) can take place within a shorter period of time over a smaller area.

International gm/cc promoter Roland Bunch states that to keep farmland productive, a minimum of 10 to 25 tons of organic matter (fresh weight) is needed per hectare per year. Fortunately, most of the gm/ccs planted by the Sri Lanna farmers are capable of adding these levels and more. For example, lablab can produce 25 to 40 tons of biomass per hectare, and jack bean can supply 40 to 50 tons. All of the legume crops that are used can fix at least 80 kg N/ha per year (see Table 1).

Unlike gm/cc systems for farms in temperate climates, the legumes produced in the Sri Lanna complex are not cut down at flowering stage and incorporated into the soil. Instead, they grow through their full life cycle and seeds are harvested. Residues are allowed to cover or partially cover the soil surface and slowly decompose.

Multifunctional gm/ccs

The adoption and long term usage of gm/ccs among the Sri Lanna farmers can be attributed largely to the multifunctional benefits of these legumes. Some of the advantages include:

- **Application as green manure cover crops,** which: 1) control weeds over a period of 4 to 8 months; 2) cover and protect the soil; 3) contribute considerable amounts of organic matter to the soil; and 4) fix significant amounts of nitrogen.
- **Household food value;** particularly the tender pods of rice beans and black beans (though the dried seeds of rice beans and black beans are consumed by local farm

families only on a limited basis). Peanut is readily consumed. Only the tender pods of jack bean are eaten (mature seeds are somewhat toxic).

- The **marketability** of each legume; this is probably the most attractive benefit of the legume crops.

Table 1 – Comparison of weed control, nitrogen fixing rate, biomass production, marketability and consumption of green manure cover crops produced in the permanent hill fields of Sri Lanna

Green manure cover crop variety	Controls weeds	Nitrogen fixation rate (kg/ha)	Reports of biomass produced (t/ha) fresh weight	Marketability in northern Thailand	Consumption
cowpea/black bean (*Vigna unguiculata*)	Good	73-354 (Silva and Uchida); ~ 80 (Bunch)	≤ 35 (PROTA)	Marketable in various locations	Edible tender pods and dried beans
rice bean (*Vigna umbellata*)	Good	~ 80 (Bunch)	≤ 33 (Ecocrop)	Marketable in various locations	Edible tender pods and dried beans
jack bean (*Canavalia ensiformis*)	Good	240 (Bunch)	40-50 can be obtained (Ecocrop)	Limited market	Edible tender pods; dried beans are toxic
lablab bean (*Lablab purpureum*)	Good	220 (FAO); 130 (Bunch)	Yields of 25-40 (Ecocrop)	Marketable in various locations	Edible tender pods for garden varieties; edible dried beans for field varieties.
peanut/groundnut (*Arachis hypogaea*)	Fair	72-124 (Silva and Uchida)	13.17 (Weerasinghe and Lathiff)	Widespread market	Seeds readily consumed

Compiled from various sources

Cropping schedule and production methods

The Sri Lanna farmers follow an informal annual relay cropping schedule. Much of the following description of the cropping schedule and associated production practices is described by Somchai and Prinz in *Voices from the Forest*.

With March and April field work (the last portion of the dry season), weeds are hoed out with crop and weed residues often piled and burned. However, since the late 1990s, many farmers in the area have begun to implement a no-burn approach, as they better understand the value of crop biomass conversion into soil organic matter. As a result, prior to rainy season crop production, plant residues are often arranged into contour strips. Increased crop diversity in the permanent hill fields, including fruit trees, has also caused farmers to restrict dry season burning.

Another factor that has led to decreased burning of residues is the widespread use of herbicides. According to the Palaung, initially only hoeing was used to control weeds prior to establishing the corn crop in May and the gm/cc crops in August. But around 1990, labor challenges and local availability of farm chemicals led the Palaung farmers to adopt herbicides such as glyphosate and paraquat dichloride. With herbicide use prior to the establishment of both corn and legumes, considerably less hoeing is required to eradicate the weeds. Therefore, a minimum tillage approach has evolved.

Lablab bean planted within corn

When the rains begin, hybrid corn (adopted in the late 1990s) is often planted along with secondary crops such as wax gourd and pumpkin. The planting distance for the corn is 70 cm by 50 cm (28 in. x 20 in.).

Farmers also often plant two crops of peanut per rainy season. Long term peanut seed storage is difficult, so a small early crop is established at the beginning of the rainy season, primarily for seed production. This helps to ensure enough fresh peanut seed for the main crop, which is established approximately four months later.

In August through September, weeds are eradicated and legumes are then planted between the corn rows. Lisu farmers plant rice bean and lablab bean at a spacing of 70 cm x 50 cm, and use a planting distance of 70 cm x 30 cm (28 in. x 12 in.) for cowpea (Table 2). Nam Saeng Loongmuang reports that the Palaung plant several seeds per hill; peanut hills are spaced 25 cm (10 in.) apart, and rice bean and black bean approximately 30 to 40 cm (12 to 15.8 in.) apart. Lablab bean hills are spaced 1 m apart.

Table 2 – Reported and recommended planting distances and seeding rates for green manure/cover crops in the permanent hill fields of Sri Lanna

Green manure/cover crop variety	Approximate planting distances (reported and/or recommended*)	Calculated Seeding Rates** kg/rai (1600 m²)
cowpea/black bean (*Vigna unguiculata*)	70 cm x 30 cm (Lisu) 40 cm x 30 cm (Palaung) 30 cm x 25 cm (recommended)	3.05 (Lisu) 5.33 (Palaung) 8.53 (recommended)
rice bean (*Vigna umbellata*)	70 cm x 50 cm (Lisu) 40 cm x 30 cm (Palaung) 40 cm x 30 cm (recommended)	1.83 (Lisu) 5.33 (Palaung) 5.33 (recommended)
jack bean	50 cm x 50 cm	42.5 (recommended)

(*Canavalia ensiformis*)	(recommended)	
lablab bean **(*Lablab purpureum*)**	70 x 50 (Lisu) 1 m x 1 m (Palaung) 70 cm x 50 cm (recommended)	7.31 (Lisu) 2.56 (Palaung) 7.31 (recommended)
peanut/ground nut **(*Arachis hypogaea*)**	25 cm x 25 cm (Palaung) 50 cm x 20 cm (recommended)	50.18 (Palaung) 31.36 (recommended)

* Recommended planting distances (for optimum ground cover and nitrogen fixation) from various sources.
**Planting rates were determined using 4 seeds per hill at either farmer or recommended planting distances.

In September, the dried stalks are pushed down as the corn crop is harvested. Farmers also step on the young bean vines, which stimulates more branching and inflorescence. By October, the bean vines usually provide full soil coverage.

Legumes are harvested at different times. The main peanut crop is ready for harvest in November and December. Cowpea (black bean) is harvested from December through January, and rice bean from January through February. Lablab is harvested from late February through March.

Harvest and yields

Individual pods of black bean (20 cm/8 in. long), lablab (4 to 5 cm/2 in. long) and jack bean (up to 30 cm/1 ft. long) are collected when the mature pods are dry. Harvested pods are spread out for further drying before being placed in sacks and beaten or trod upon to release the seeds.

Rice bean is harvested differently. The 10 cm (4 in) long pods are produced in small clusters and are difficult to collect individually. Instead, farmers use sickles to cut the entire mass of mature vine. After adequate drying, the vines are beaten with long sticks over a large canvas to thresh the seed. The released seeds are then gathered, dried and cleaned. Threshed vines are usually left in the field to decompose.

Threshing rice bean in the field

Peanut pods are produced underground, so roots and pods are dug at harvest. Uprooted pod clusters are dried in the field. Individual pods are dislodged from the root system by beating them against the edge of baskets. After further drying, the peanuts are sold (either shelled or unshelled; most farmers market unshelled peanuts).

Yawt Loongmuang (in Pang Dang Nai community) estimates, that one rai of productive permanent hill field can yield approximately 15 *tang* of dried black bean seed, 25 *tang* of rice bean seed, 15 *tang* of lablab bean seed, or 50-100 *tang* of peanut pods.

Corn yields in the relay-cropped fields are higher than the average. During the late 1990s, Somchai and Prinz reported that the average yield of non-hybrid corn produced in the relay-cropped fields of Huai Nam Rin was 3.05 tons/ha. This yield, obtained without the use of chemical fertilizers, was almost 50% above the national average. Except for tender roasting ears consumed by households and small amounts saved as animal feed, practically all the corn crop is sold to middle men. Corn recently sold for 6 to 8 baht per kg and is the main source of farm income.

However, with continual crop production, relay cropping with gm/ccs has not been adequate to maintain satisfactory corn and upland rice yields in many of the steep, permanent fields, especially those comprised of quartz schist soils. Over time a large number of these tracts have become degraded to the point where they are no longer useable for annual field cropping. As a result, many of these fields are being converted into mixed orchard/agroforestry plots.

The gm/cc market

All five types of gm/ccs used as relay intercrops are marketed through middlemen who purchase crops in each village. Depending on the market, farm gate prices for lablab, black beans and rice beans vary. According to Yawt Loongmuang, 2011 prices for all three beans were attractive, with black bean selling for 19 baht ($0.63 US)/kg; rice bean for 24 baht ($0.80 US)/kg; and lablab bean for 25 baht ($0.83 US)/kg.

Due to oversupply, bean prices can also drop to less profitable levels. Farmers generally hedge by planting two or more types of gm/ccs each growing season. Should prices be too low to make the sale of the beans worthwhile, cooked rice bean, lablab and cowpea could possibly be used to supplement pig feed rations.

A small number of farmers in the area produce jack bean, even though marketing opportunities for jack bean are much more limited. Alea Santya, who farms in Chiang Dao's Na Wai community, reports that in 2011 jack bean was purchased by a Chiang Mai middleman for 20-25 baht per kg.

Black cowpea and rice bean are used in various foods such as bean paste, so they are both consumed domestically and exported. Lablab bean is processed regionally into a cheap, salty snack and is also exported. However, the only known regional use of the jack bean crop is for use as gm/cc seed.

Peanuts produced in Thailand are marketed both domestically and internationally. With a reliable market, the acreage of production in Chiang Dao has increased significantly over recent years.

Chemical inputs

Despite the agroecological benefits of employing gm/ccs to fix nitrogen, produce soil organic matter and smother weeds, the relay cropping farmers of Sri Lanna have applied agricultural chemicals for many years to produce their gm/ccs. These mainly include herbicides, pesticides and hormones; chemical fertilizers have generally not been used for relay cropping.

Prior to the establishment of both corn and gm/cc crops, a wide spectrum of weeds are killed back by glyphosate and paraquat dichloride. To ensure adequate die-back, farmers admit to applying rates higher than recommended. Costs are increasing (the 2011 cost of 5 liters of paraquat dichloride was 750 baht, compared to 500 baht a few years ago), but the present cost is still considered affordable.


Herbicides applied to relay cropped fields

I asked farmers what they would do if the cost of paraquat was to rise closer to 1000 baht. They replied that they would have to cut back on the use of the herbicides, perhaps focusing only on areas where weeds are most problematic.

In addition to their herbicide use, farmers are also spraying hormone on each type of bean to boost flower and pod production. They generally use three applications during the period from early flowering to early pod production. Additionally, a caterpillar (possibly the bean pod-borer, *Maruca testulalis*) infests cowpea and rice bean, requiring application of pesticides such as synthetic pyrethroid. Jack bean is also affected by a pod borer, but lablab bean and peanut are not. Alea Santya reports that some growers use a chemical insecticide to control the jack bean pod borers, while others apply neem and other natural sprays.

Despite considerable reliance upon farm chemicals for gm/cc production, many farmers expressed health and environmental concerns.

Long term rotational cropping strategies with gm/ccs


Relay-cropped peanuts

In addition to relay cropping corn and legumes, many of the Sri Lanna farmers continue to produce upland rice on a limited basis in their permanent hill fields. Most would prefer to grow upland rice continually as the main staple crop, but the grain requires fertile soil. Also, farmers report that long term production of upland rice on the same land leads to pest problems such as rice stem borers.

Fortunately, the use of gm/ccs in the accelerated improved seasonal fallow system enables ongoing maintenance of permanent hill field soils. This allows for occasional production of upland rice (every two to three years), particularly on less-degraded land.

Peanut is another crop that farmers avoid planting every year. They prefer to rotate peanut with relay-cropped corn and gm/ccs at least every other year. If peanut is continually cropped on the same plot of land, yields decline due to increased levels of disease and loss of soil fertility. And despite being a legume, peanut is not considered a very effective gm/cc due to modest amounts of biomass production as well as soil disturbance during harvest. For long term production of peanut on the same plot of land, farmers insist that additional inputs and expenses would be necessary to maintain adequate soil fertility and disease control.

Can gm/cc relay cropping be adopted everywhere?

Chemical fertilizers remain out of reach of many who cultivate marginal lands, due to the expense and limited availability. Production and application of natural fertilizers and soil amendments, such as compost, is impractical for large fields where manual labor is required. Gm/ccs are probably the most feasible option to supply adequate amounts of biomass and nitrogen to permanent fields and rice paddy where traditional fallows are not an option.

However, despite the Sri Lanna farmers' success with relay cropping gm/ccs, introducing similar approaches to other communities may be challenging. For example, as long as traditional farming practices remain an option for farmers who practice shifting cultivation, widespread adoption of gm/cc-based accelerated improved fallows is unlikely. Pest issues and the lack of markets may be other obstacles toward promoting gm/cc relay cropping systems.

A summary of strengths, weaknesses and opportunities for promoting gm/cc relay cropping systems

Strengths associated with the use of gm/ccs in the Sri Lanna relay cropping system include:

- Gm/cc seed sources are self-sustaining, as they are produced by the farmers themselves.
- Each type of gm/cc is multifunctional, maintaining soil fertility but also providing supplemental food and significant household income.
- The gm/cc relay cropping system has spread farmer-to-farmer with little outside technical intervention.
- Available market channels have been instrumental in the spread of relay cropping gm/ccs.

Rice bean

Weaknesses related to relay cropping gm/ccs in Sri Lanna and elsewhere:

- Considerable amounts of petroleum-based agricultural chemicals are being incorporated into the relay cropping system (especially labor-saving herbicides), adding to production costs and creating significant health and environmental risks.
- The use of gm/ccs alone is not enough to prevent steep quartz schist soils from degrading.
- Farmers use varied planting distances and seeding rates, often resulting in inefficient use of seed and space.
- The Sri Lanna gm/cc relay cropping system only provides beneficial soil coverage during the late rainy season and early to mid dry season.
- Unlike in Chiang Dao, markets for gm/ccs are not widespread, limiting the opportunity for introduction of similar production systems elsewhere.
- In places where gm/ccs have been introduced on a limited basis, rodents can reportedly target small plantings of legumes.

Opportunities to help overcome the gm/cc relay cropping challenges in Sri Lanna and elsewhere:

- Technical/development agencies and farmers should research how to extend the period of gm/cc cropping so that it will include the beginning of the rainy season. This could improve the effect of natural weed control by keeping the soil surface covered longer. One approach might be to intercrop non-climbing, somewhat shade-tolerant jack bean with corn, prior to relay cropping other gm/ccs.
- Agencies and farmers should test the effectiveness of locally available natural pesticides (e.g. neem, wood vinegar) to determine safe and low-cost controls of various gm/cc pests, such as pod borers.
- Effective soil conservation measures (e.g. contoured vegetative strips) should be employed along with gm/cc production, to prevent or slow the degradation of soil on sloping land.
- Additional regional gm/cc evaluations are needed to identify multi-functional gm/ccs that could potentially occupy local market niches and be compatible with local food preferences.
- Opportunities for expanding gm/cc market channels must be studied, to make gm/cc production profitable to farmers throughout the region.

A fully illustrated slide presentation about gm/cc relay cropping in northern Thailand can be accessed via this link: http://www.echonet.org/repository#1006:d:Green Manure Cover Crops .

Limited quantities of lablab bean, black bean (cowpea), rice bean and jack bean seed can be requested from the ECHO Asia Seed Bank (AsiaSeedBank@gmail.com).

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