

Green Manures for Highland Paddy in a Mountainous Area

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ABSTRACT

An evaluation of opportunity to improve productivity of highland paddy with green manure was conducted as a participatory research in collaboration with farmers of Tee Cha village, Sop Moei sub-district, Mae Hong Son province in northern Thailand. Four species of legumes (Lablab purpureus, Vigna umbellata, Canavalia ensiformis and Mimosa invisa inermis) were grown before the farmer-managed rice crop (cv. RD21) in farmer's highland paddy field. The biomass and nutrient contents of the legumes and rice yield and yield component were evaluated. Rice yield in the farmer's field was increased for 16-44% after green manuring, depending on the legume species, with V. umbellata having the highest effect on rice yield, followed by C. ensiformis. Farmers evaluation of the green manure legumes agreed with measurement of nitrogen content of the legumes and subsequent rice yield. The experiment and participatory results suggest that there is an opportunity to improve rice yield in highland paddy with green manuring.

Key words: Highland paddy, Green manure, Paddy terraces, Soil fertility, Crop productivity

INTRODUCTION

To ensure rice sufficiency, highland paddy has been developed as one of the alternative systems to upland rice in traditional shifting cultivation for ethnic minorities throughout the mountainous areas of Southeast Asia such as Laos (Linguist et al., 2007) as well as northern Thailand (Walker, 2001). Many narrow strips of small river valleys were transformed into paddy terraces with supplementary irrigation from natural springs and waterways. Despite many successful developments in the past, productivity of highland paddy remains low in most places, depending upon natural fertility of the soils. The application of chemical fertilizers is uncommon and the use of farmyard manures such as cow dung is limited with small number of livestock kept in the village. No further attempt has been made to restore or improve the fertility of the existing highland paddy soils. In this situation, the incorporation of green manures during the fallow periods in the dry season may offer a viable solution to the problem.

Leguminous plants are grown as green manure and turned into the soil to improve soil productivity (Singh et al., 1991). For lowland rice paddy, *Sesbania cannabina* and *Crotalaria juncea* have been reported to accumulate N at very high rates (Lauren et al., 1998). Within 45 days, accumulation of 225 kg N ha⁻¹ has been recorded in *S. cannabina* and up to 169 kg N ha⁻¹ in *C. juncea* (Malee et al., 1992). An analysis of 222 measurements in rice-based cropping systems showed that legume green manures accumulated from 2 to 324 kg N ha⁻¹ (Becker et al., 1995). The positive effect of green manure on paddy yield has been reported by Bhatti et al. (1983), that sesbania green manuring increased rice grain yield up to 72%. In the Northeast of Thailand a pre-rice crop of sesbania (*Sesbania rostrata*) – cowpea (*Vigna unguiculata*) combination increased rice yield by 0.8 t ha⁻¹ (Toomsan et al., 2000). Many species of legumes are used in agriculture for their ability to fix nitrogen (N) from the atmosphere in symbiosis with the nodule bacteria. In

the Hill and Terai regions of Nepal, Maskey et al. (2001) have reported from on-farm surveys of N_2 fixation conducted between 1994 and 1999, involving summer legumes and winter legumes. Estimates of total N fixed (including roots) were 59 kg N ha^{-1} (soybean), 28 kg N ha^{-1} (*Vigna mungo*), 153 kg N ha^{-1} (*Apios americana*), 72 kg N ha^{-1} (*Lens culinaris*), 84 kg N ha^{-1} (*Cicer arietinum*), 412 kg N ha^{-1} (*Cajanus cajan*) and 80 kg N ha^{-1} (*Lathyrus sativus*). The use of grain legumes provides the possibility for the pods and grain to be harvested whilst leaving the residues to be turned into the soil. For example, *V. radiata* produced $0.9 \text{ ton grain ha}^{-1}$, and crop residues that gave an increase in rice yield equivalent to $25 \text{ kg N-fertilizer ha}^{-1}$ (Meelu and Morris, 1988). However, not all grain legumes improve soil fertility, especially if the crop residue is also removed from the field. For example, soybean has often been shown to deplete soil N (Kreebubol, 1991; Ying et al., 1992; Wang et al., 1993). This paper explores ways in which highland farmers could integrate green manure crops for their paddy systems.

MATERIALS AND METHODS

In February 2007, four species of legumes (*Lablab purpureus*, *Vigna umbellata*, *Canavalia ensiformis* and *Mimosa invisa inermis*) were grown (Figure 1) before rice crop (RD21) in a farmer's field in $5 \times 5 \text{ m}^2$ plots in 3 replicated blocks. Biomass and nutrient contents of the legumes were measured before land preparation for rice in mid of June. At land preparation for the rice crop, the legume biomass was incorporated. The farmer-managed rice crop (cv. RD21) was planted in early of July. At maturity, rice dry matter and grain yields were recorded. Plants were cut at ground level for threshing to obtain grain and straw weight separately. The rice grain was sun-dried for 3 days before weighing, and moisture content adjusted to 14%. Straw was oven dried at 80°C for 48 hours before weighing. Sub samples of 10 hills were taken from each plot for yield component determination, i.e. number of tillers hill^{-1} , number of panicles hill^{-1} , % filled grain, % empty grain and individual grain weight. Number of hill m^{-2} were counted from the sample area and 100 grain weights were obtained from sub-samples. Tiller and panicle numbers were counted on individual hill basis. Plant samples were kept for nutrient analysis in laboratory. The legumes evaluation and selection by farmers were made in the farmers' field in a field day that involved farmers in Tee Cha and 4 other neighbouring villages (Tiyapur village, Huai Chai Yong village, Leykoe village and Huai Kong Mula village.) (Figure 2) The questions were put to the farmers while in the field. Group discussion was carried out as a final session for all participants to discuss their findings in the field and opportunity for the future. These activities are shown in (Figure 3.)



Figure 1. Four species of legumes.

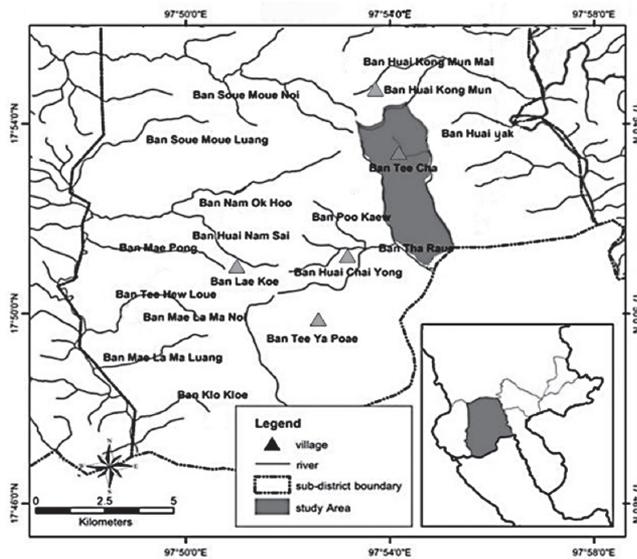


Figure 2. Working area.



Figure 3. Farmers' participation.

RESULTS

On a whole, farmers gave *V. umbellata*, as the most preferred green manure species. This was based on its heavy biomass production over a period of only 115 days from sowing at about 11.4 t ha⁻¹, providing at least 220 kgN ha⁻¹, 30 kgP ha⁻¹ and 270 kgK ha⁻¹. It was also recorded that the yield of the following rice after *V. umbellata* could be increased by almost 1.0 t ha⁻¹, as comparing to the next rice crop with conventional practice. Some farmers also prefer *C. ensiformis* as another green manure crop. The dense stands of both *V. umbellata* and *C. ensiformis* have provided complete shading and totally suppressed weeds prior to plowing and preparing land the next wet season rice crop.

Table 1. Dry matter of legumes.

Species	Biomass (ton/ha)
Nil	5.13 D
<i>Lablab purpureus</i>	10.11 B
<i>Vigna umbellata</i>	11.44 B
<i>Canavalia ensiformis</i>	13.67 A
<i>Mimosa invisa inermis</i>	7.45 C
LSD _{0.05}	2.2

Mean with the same letter (A, B,C,D) are not significantly different at $\alpha=0.05$.
CV = 2.228

Table 2. Nutrient content of legumes.

Species	Nutrient content (kg/ha)		
	N	P	K
Nil	81.79 D	13.08 C	86.41 D
<i>Lablab purpureus</i>	319.48 B	40.78 A	300.27 A
<i>Vigna umbellata</i>	223.46 C	28.60 B	274.18 B
<i>Canavalia ensiformis</i>	416.12 A	39.20 A	215.58 C
<i>Mimosa invisa inermis</i>	333.50 B	28.53 B	226.80 C
LSD _{0.05}	22.15	3.98	25.97

Means with the same letter (A, B, C, D) are not significantly different at $\alpha=0.05$.
CV = 2.228

Table 3. Rice yield (at 14% moisture).

Species	Rice Yield (at 14% moisture) (ton/ha)	% increased
Nil	2.05 D	
<i>Lablab purpureus</i>	2.79 AB	36.10
<i>Vigna umbellata</i>	2.96 A	44.39
<i>Canavalia ensiformis</i>	2.55 BC	24.93
<i>Mimosa invisa inermis</i>	2.38 CD	15.61
LSD _{0.05}	0.34	

Means with the same letter (A, B, C, D) are not significantly different at $\alpha=0.05$.
CV = 2.228

DISCUSSION AND CONCLUSION

There is an opportunity for highland paddy to improve its productivity with green manuring. The increasing of highland paddy yield by green manure legumes indicated that the positive contribution of green manure is something commonly known among the highland farmers but the practical implication for highland paddy has not been realized due to water limitation in the dry season, unavailability of seeds, damage from livestock and bad smell of green manure crops such as lablab which is commonly grown in the upland fields of many lowland villages in Mae Hong Son. Farmers also discussed the biophysical constraints of their paddy terraces and these have led

to the examination of highland paddy with respect to biophysical setting and ecological aspect of the paddy terrace in the village landscape.

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