Promoting the adoption of sustainable land use practices in maize-based systems in northwest Vietnam[1]

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Abstract

The north-west has a very large monoculture maize growing areas in Vietnam, with annual growing areas of more than 300,000 ha, mainly on the sloping land. Therefore, sustainable land use becomes the leading priority in the agriculture sector in the region. Several farming practices for sloped land conservation have been studied and applied in corn culture in the north-west. However, these pratices have not been widely applied in practical. Agricultural research is typically conducted on a small scale by researchers, without significant participation of farmers or considerations of local technical abilities in the process of testing, evaluating and adjusting the techniques for adaption to the the specific local conditions.

In order to promote sustainable land use practices among smallholder farmers, we have applied a participatory approach to research activities in maize-based systems in the northwest highland since 2009. Through two research projects in the northwest, the 'Improved market engagement for sustainable upland production systems' project funded by ACIAR and the ADAM project funded by AFD and CIRAD, the evaluation, adaptation and demonstration of new land and crop management practices were undertaken in farmers' field. Farmers and local officers selected the technical options for trial, evaluation, demonstration and expansion, to ensure suitability for local conditions. They also evaluated the impacts, strengths, weaknesses and economic efficiency of each innovation, and determined the necessary adjustments so that the techniques become more relevant with the soil, geography, investment capacity of farmers and usage purposes. Additionally, we managed to link with the local extension agencies, enabling farmers to recognise the necessary assistance from local authorities and receive support to learn about the newly introduced practices and overcome barriers in the application of these practices.

Although still at limited scale, the results showed that with the strong engagement of local extension agents, community leaders and farmers, sustainable maize production practices on sloping lands were adopted, implemented and further expanded by farmers in many villages and communes in northwest Vietnam. Using the outreach strategy designed by the ACIAR project, more than 2500 householders in Yen Bai, Son La and Lai Chau were been supported in 2014 by the extension system in the selection and application of relevant practices. In Son La, Yen Bai, two practices were selected, including (i) land covering and minimum tillage, and (ii) intercroping with legumes. In Lai Chau, prolongued cropping season and intercroping with legumes became widely practised.

Keywords: erosion, northwest Vietnam, conservative agriculture, maize, land use.

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1. Introduction

In the northwest, maize is a major and important crop, annual maize growing area up to nearly 300,000ha, mainly on the sloping land, about 15-25 sloping degree. Therefore, the sustainable management of maize production system and sustainable land use become one of the high priority of agriculture sector and provinces in the region.

In the last two decades, much effort has been spent to seek technical solutions for this issue. Achievements are the cultue practices for the purpose of protecting and regenerating soil fertility. (Le et al. 2003, Le & Ha, 2008). However, the application of these practices is still limited. Fertilisers required have been increasing in order to maintain crop yield and therefore erosion becomes more severe (Gunnar et al. 2012). The reasons include barriers that prevent farmers (Pham Thi Sen, 2014), and limitation in the approaching methods of dissemination, transferring and supporting farmers in applying these practices (van de Fliert et al., 2012).

Under the such circumstance, during 2009-2014, the project AGB/2008/002 funded by ACIAR and the ADAM project supporting approaching methods for agricultural ecology in northwest funded by AFD and CIRAD, studies have been undertaken in order to promote the application of sustainable land use in culture system with maize as the major crop on sloping land in the northwest. The results indicated that the increase of participation of farmers, authorities and local extension workers in the designing, evaluating, and adjusting the technical packages was an effective solution for promoting pratical application. Additionally, the integration in the local extension programs enable smallholders to access information, improving capacity and being supported financially, so that they were able to overcome the barriers in the early years of practical application. By new approaching methods, in 2014, some sustainable sloping land use practices were improved in Son La, Yen Bai and Lai Chau.

2. Methodology

Nornally, every year, in the end of dry season, farmers in the northwest clear and burn their farms, while waiting for the coming rainy season, they plough their land to divide the soil bed, sowing maize seed. Therefore, in the early rainy season, while maize has not been planted or the crop is still at early stage, the land was porous and uncovered. At this stage, during May and June, erosion becomes more severe (Figure 1). The subjects of the study, therefore, are sloping land erosion mitigating pratices, particularly at the early rainy season, including:

(1) minimum tillage and keep the land covered;
(2) Intercropping with legume;
(3) Developing season 2 after the season 1;
(4) Preparing terraced field to grow maize;
(5) Intercropping with weed for cattle on the contour lines

Study sites include several communes in Son La, Lai Chau and Yen Bai. The selected communes have varied climate, soil, cropping seasons and ethnic group component. The selection based on the variation exhibits significance in determination relevant practices and necessary adjustment for the technical packages in certain circumstance and condition.

The research activities include (Figure 2): (i) enhancing effective participation of local officers, core farmers, (ii) developing the farmer participatory network in selection, experimenting and

evaluation and demonstration of the sustainable land use practices, and (iii) supporting extending application of practices through integration into local extension system.

All activites were undertaken with the participation of provincial Department of Agriculture and Rural development and extension system, leaders in the commonues and vilages and maize growers in the study areas. The screening, evaluation and demonstration were undertaken by farmers on their own farms, with support from researchers, extension workers and core farmers. By this way, farmer and local officers were those who made the decision in selecting the technical package for screening, evaluation, demonstration, and application development. They were also asked to evaluate the impacts, the strengths, weakness and economic efficacy of each package, and to decide necessary adjustments required to improve the packages to be more relevant with soil condition, geographic and investment ability and using purposes of householders.

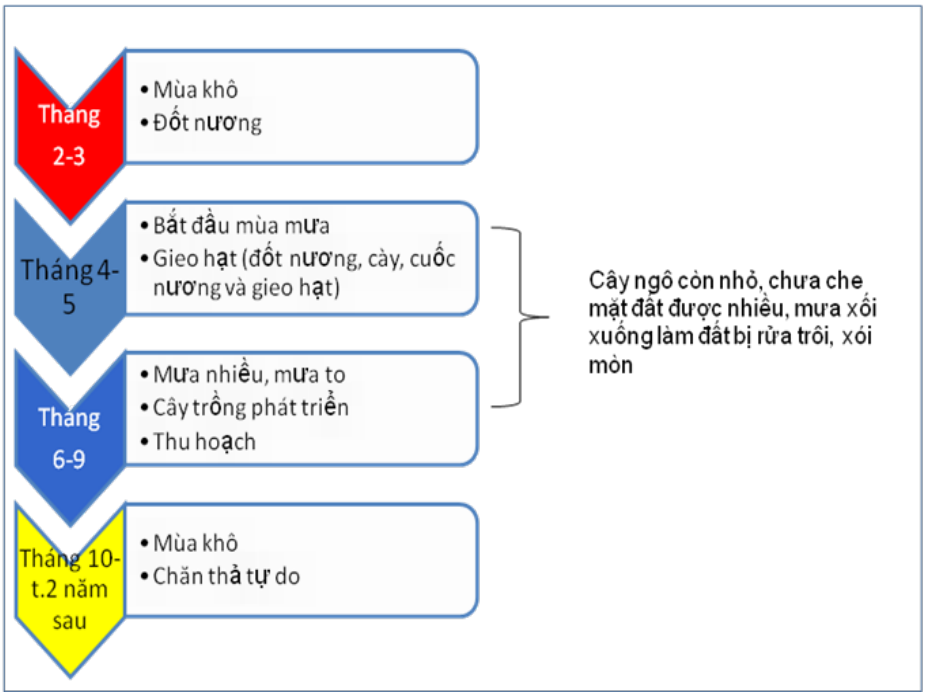

Figure 1: Soil erosion risks in early rainy season (Nicetic, 2011)

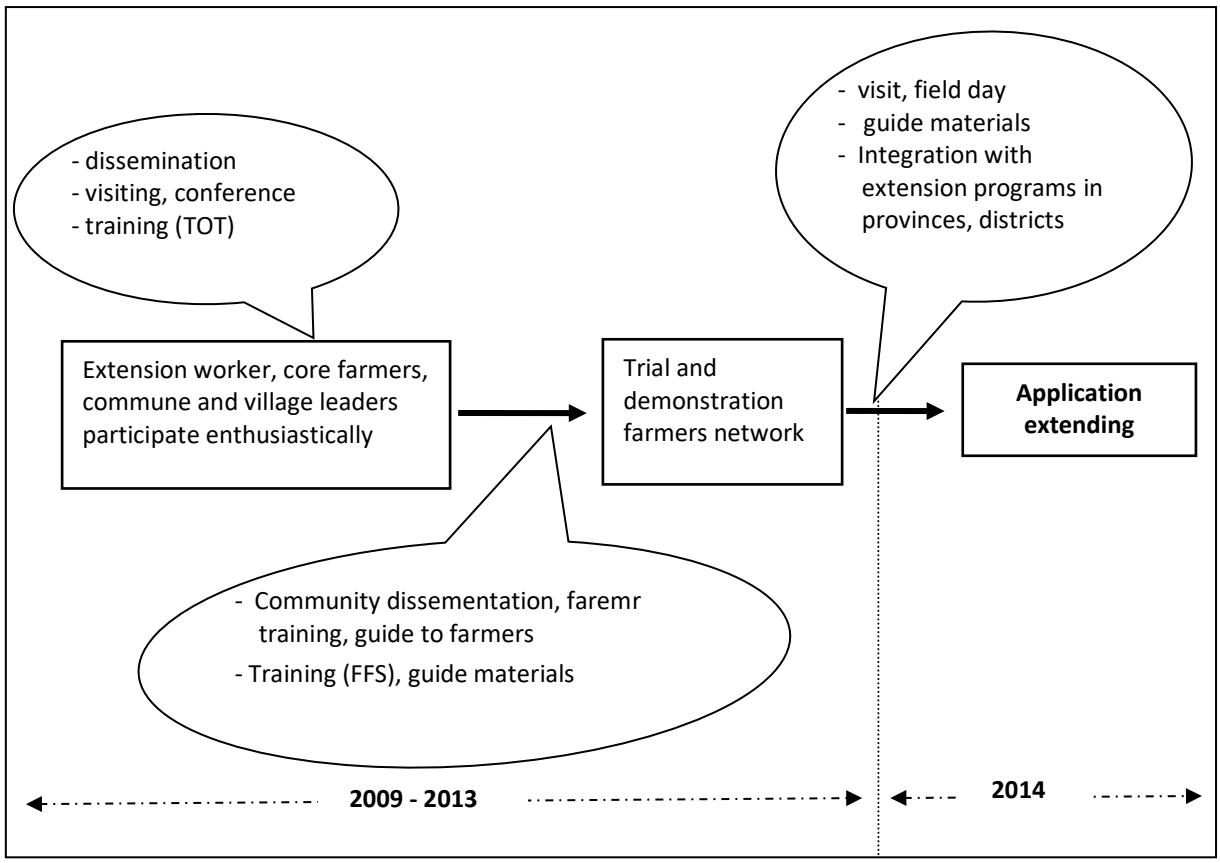

Figure 2. Stages and major research activities

3. Results and discussion

3.1. Promotion of adoption of sustainable land use practices

In Son La, Lai Chau and Yen Bai, in each about 20 extension workers at province, district and commune levels were trained in the principles of sustainable culture on sloping land, and sustainable land use practice. They, thereafter, were asked to train farmers using farmer field school. Additionally, some core farmers were selected for improving capacity. This group includes women association members, and farmer association members in commune and village levels. The core farmers, after being trained, were asked to convince and guide other farmers to implement the practices. Their farms were used for field visit, training and sharing experiences. As a result, a network of 181 householders was established to evaluate and demonstrate the sustainable land use practices (Table 1).

In combination with extension program in provinces and districts from the farmer networked stated above, in 2014, the application of sustainable land use practices was extended in the three provinces. In Son La, through provincial extension network, more than 2270 householders were trained and supported technically to apply mulching and minimum tillage, intercropping and partially overlapping season, in the total area 2800 ha in 12 districts and Son La town.

In Yen Bai, Van Chan district delivered a policy encouraging economic aspect so that householders were able to solve difficulties in the first year of application. Results, in 2014, indicated that in Cat Thinh commune, although without financial support, more than 100 householders continued using land covering and minimum tillage.

Table 1: Household farmers participating monitor, evaluation and demonstration of the practices

Location	Total number of household	Ethnic group	Season 1	Season (*)
Văn Chấn district, Yên Bái province (Sơn Thịnh and Suối Giàng communes)	30	H'Mong, Thái	Maize intercropping with stylo weed	Maize intercropping with stylo weed
			Maize	Maize intercropping with vine legume
			Maize	Maize intercropping with velvet bean
Mộc Châu dsitrict, Sơn La province (Chiềng Hắc, Mường Sang and Phiêng Luông communes)	71	Piềng Lán, Dao, Thái, Sinh Mun, Tông Hán	Maize intercropping with groundnut	
			Maize intercropping with soybean	
			Maize intercropping with stylo weed	Maintaining Stylo
			Maize intercropping with vine legume	Vine legume
			Maize intercropping with velvet bean	Velvet bean
			Covering and minimum tillage	
			Covering and minimum tillage	Incresing cropping season: legume
			Covering and minimum tillage	Increasing cropping season: oat
			Covering and minimum tillage	Increasing cropping season: maize
Mai Sơn district, Sơn La province (Chiềng Chăn, Nà Ớt and Cò Nòi communes)	30	Thái	Tiểu bậc thang	
			Covering and minimum tillage	
			Covering and minimum tillage	Incresing cropping season: legume
Tam Đường district, Lai Châu province (Tam Đường and Bản Bo communes)	47	H'Mông, Dao, Kinh, Mán	Covering and minimum tillage	
			Maize-groundnut intercropping	Incresing cropping season: maize
			Maize-soybean intercropping	
			Maize-soybean intercropping	Incresing cropping season: maize-soybean
			Maize-vine legume intercropping	Vine legume
			Guatemala weed	
Sìn Hồ, tỉnh Lại Châu (Tả Ngảo and Làng Mô communes)	3	H'Mông	Covering and minimum tillage	
			Tiểu bậc thang	

** In Yên Bái, two maize growing seasons were already common practice in the large area, so the innovation of a two-season system introduced in other project areas was not applied in Yên Bái as part of this project.*

In Lai Chau, in Tam Duong district, with effort of people committee and district communist party, adding season 2 resulted in biomass for soil covering materials and increasing household income. This model has been widely applied.

3.2. Assessment of impacts and determination of barriers preventing householders in the northwest from applying sustainable land use practices

The results indicated that, in practical, protective and renovative impacts of these above practices in the maize field were recorded by farmers and local officers. However, regarding growth, yield and economic efficacy of maize production, farmers have recorded not only positive impacts, but also negative impacts of these practices.

3.2.1. Minimum tillage and soil covering with plant residues (DMC)

- ***Effects on the germination and pests***

The covering layer probably has negative impact on the germination of maize seeds and intercropped crops. It has less been mentioned, due to small scale experiment in which the seeding was managed 'perfectly' by researchers, under this condition, eliminating impacts of mulching materials affecting germinating. Therefore, in the reports and scientific papers, covering layer was regarded as a factor to maintain soil moisture and leading to better germination and growth of the plant (Figure 3). However, in the practical, covering materials are probably still 'fresh', and farmers do not follow adequately procedures to avoid the seeds to be covered. As a result, in the farmers' field, covering layer was recorded to reduce the germination (Figure 3).

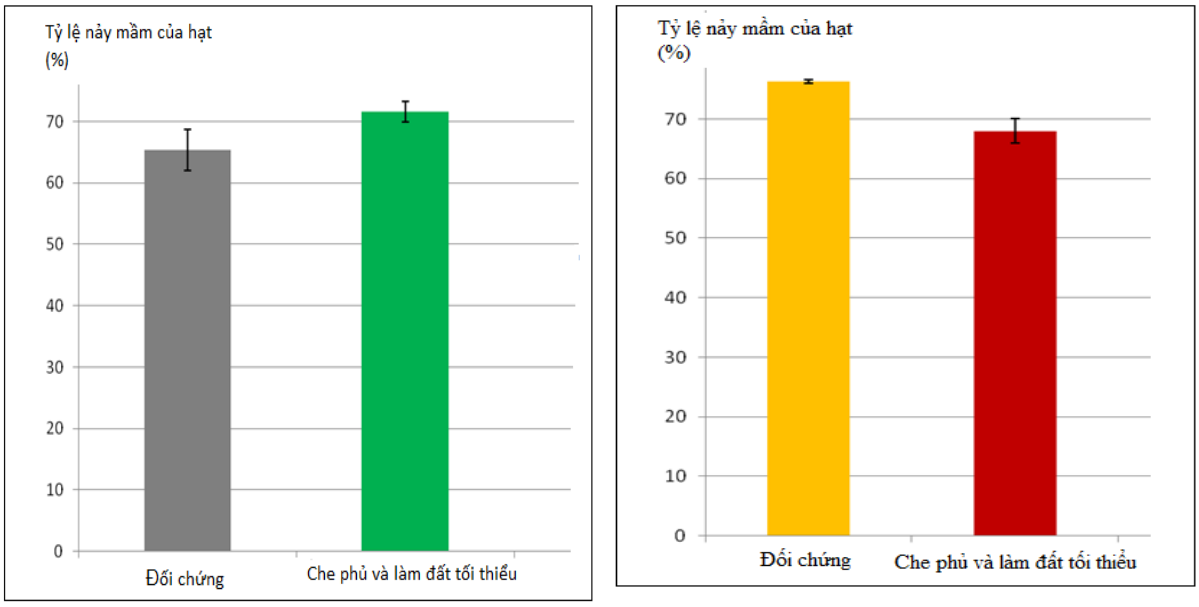

Figure 3: Average germination percentage of maize seed as the material is well managed, the maize seed was not covered by materials (left), and as maize seed was covered by covering material (right), the common maize variety in Sin Ho, Lai Chau province.

Additionally, in the farmers' field, covering layer has been thought to cause the increase in pest and rodent damage. 'If in uncovered field, a rodent is required to move to reach the seed. In covered field, a rodent founds the seed as it open its eyes'. This is a comment of a farmer in Chieng Chan, Mai Son, Son La. In order to eliminate rodent damage, he collected covering materials, and once maize plant grown up, rodent risk is no longer exist, he put the covering materials back. This solution prevented the plant from rodent damage, but the main objective of covering, erosion mitigation was not achieved.

In order to face the pest and rodent damage, researchers recommended that maize seed and covering materials should be treated prior to sewing. However, following the procedures properly by the farmers, environmental pollution elimination and ensuring community health is still a challenge.

- ***Labour and economic efficacy requirements***

Covering layer, if well managed and negative impacts on germination and young plant growth, covering layer maintains soil moisture, leading to better growth, and high yield (Figure 4). However, covering layer causes difficulty in soil preparation, dividing furrows, manuring, and sowing. This led to increasing in labour cost input for planting-which enable the proper cropping season frame (Table 2). In the current condition in the northwest, labour resources for agricultural production during cropping seasons is inssuficient. This is one of the barrier preventing householders from applying these practices, even the labour required for other time period could possibly lower than the control (Table 2).

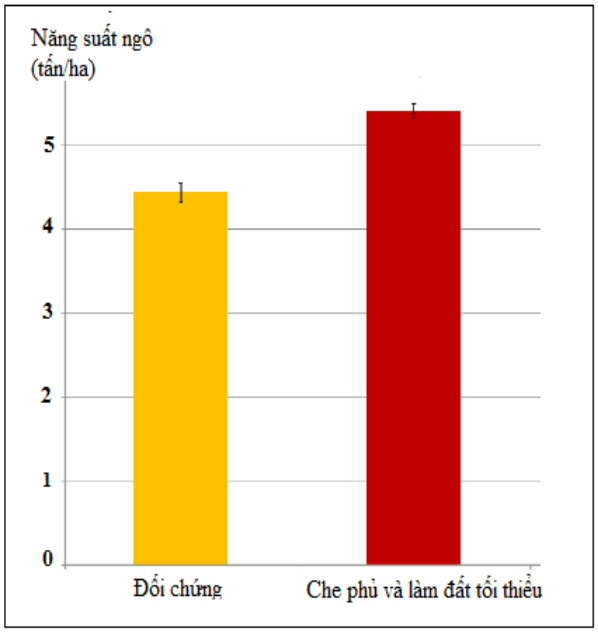

Figure 4. Maize yield as a result of covering the land and minimum tillage (Common varieties in Na Ot, Mai Son, Son la, 2010)

Table 2: Estimation of inputs and benefit of application of proper and adequate technical package*

	Soil covering and minimum tillage	Control
Labour cost (number of working day)		
Land preparation	4	4
Herbicide spraying	2	0
Burning the land (residues)	0	2
Plough entire field	0	15
Plough to make Cày/cuốc tạo hàng	6	4
Manuring, sewing, covering material management	27	14
Management (herbicide spraying)	4	4
Manuring	8	6
Harvesting	15	15
Total	***66***	***64***
Total labour cost (1000 đ)	***6.600***	***6.400***
Total material input cost(*)	***9.227***	***8.892***
Maize productivity as harvested (kg)	***10.200***	***8.500***
Total productivity	**30.600**	**25.500**
Total interest	**14.773**	**10.208**

** Based on estimation of farmers in Phiêng Luông, Mộc Châu district, Sơn La province in 2014, the year 2 of adoption of the practices*

Another difficulty reported by the farmers is lack of covering materials, particularly in the first 1-3 years. The supplementation of covering materials onto the maize field required high labour cost. While due to the wind, decomposition as time being and damaged by buffalos and cows, the remaining maize plant residues is not enough. Intercroping with legume crops and developing season 2 have been recommended as a solution for the covering material production. However, as mentioned below, application of intercropping and developing the season 2 face difficulties.

Therefore, if applied properly and adequately, covering practices and minimum tillage increased yield and net interest. However, in order for farmers to be able to apply properly and adequate technical packages, a solution to support the farmers to overcome the barriers about labour, especially during the sowing time, supplying adequate materials, proper pest abd rodent management in the first 1-3 years of application.

3.2.2. Intercropping with legume crops

Intercropping legume crops onto maize field in sloping land aism to multiple purposes, including: (i) mass production to produce covering materials, (ii) soil fertility enrichment and improving soil fertility through nitrogen fixation of legume crops, and (iii) increasing farmers' income.

In this study, several legume crops were introduced so that farmers could select a intercopping crops to apply in their own farm. These included stylo weed, 'xuc xac hoa vang', Caesalpinia, pigeonpea, cowpea, mungbean, soybean, velvet bean (*Mucuna pruviens*), vine legume (*Vigna umbellate*), and groundnut. The cropped selected by famrers includes vine legume, velvet bean,

soybean, cowpea, groundnut, stylo weed (Table 3). Farmers' assessment indicated that application of intercropping yielded positive impacts but faced some constraints.

- ***Mass production ability and soil fertility enrichment***

Anually, vine legume, velvet bean and stylo weed produced significant bio mass. Vine legume produced 1.8-2.8 tons/ha, velvet bean 3.2-4.2 tons/ha and stylo weed 3.5 and 5.5 tons/ha of stem and leaves per year, depending upon climate and soil condition. This provides the resource to improve fertility and protect the soil from erosion.

Stylo weed can remain overwinter, growth begins in the coming spring, and rapidly covering the land, fertility enrichment. However, stylo weed seed price is costly, approximately 5,000,000/ha, exceed the investment capacity of local farmers in the northwest. Moreover, physical hardness of the plant stem causes the difficulties in process to become covering materials. Due to these reasons, stylo weed is not a preferred option by farmers. Although, stylo weed can be used to renovating the heavily degenerated soil as it presents high regeneration and produces large biomass.

Velvet bean raplidly grows and covers the land after harvesting the maize plant, led to positive effects in weed control and fertility supply, particularly in the heavily degeneration, and the land required rapid recovery. However, because farmers were unfamiliar with using velvet bean as a food source for cattle, it, therefore, is not selected as an intercropping crop.

Though vine legume produces low biomass, in compared to velvet bean and stylo, its beans are rich in nutrition and easily used as food source for human and cattle. Vine legume is easily grown, less damaged by pests, therefore, it is preferred by farmers. However, the market of this bean is still not well developed, difficult to sell products.

Although soybean, cowpea, groundnut produce less biomass, they were recorded to contribute to improve soil fertility after 2-3 years of intercropping in the maize field.

- ***Labour cost effects maize yield and economic efficiency***

Intercropping with legume crops, in all cases did not reduce yield, and in many cases, it increased yield significantly (Table 3). In addition, several intercopping crops provided additional income for farmers. For example, in Chieng Hac, between 2012 and 2014, vine legume yield ranged 320-1100 kg/ha, depending upen householder and year. Vine legume bean is used as food source for human and cattle, the price upto 20,000-30,000 dong/kg. Velvet bean yield ranged 700-20,000 kg/ha. Velvet bean can be used as food for cattle after simple processing procedure, such as boiling, to remove toxicity. Cowpea and soybean yield ranged 130-160 kg/ha if receiving proper management and pest control.

However, intercropping can cause difficulty for managing the maize crop, and increase labour costs. In comparison with control, the labour cost increased by 20 day/season. Moverover, proper pest control for intercropping crops is required in order to obtain productivity. This is not really feasible in the northwest as farmers do not have knowledge and experience in legume pests and intercropping crops management procedure.Therefore, even though maize yield increased, net interest probably reduces if labour cost added to the total input investment.

Therefore, like other practices, the increase in the labour cost and management difficulty and pest control are constraints that prevent farmers from intercropping application. In addition, the lack of market of intercropping crop products such as vine legume, velvet bean limits extending capacity of householder farmers.

Table 3: Impact of intercropping with legume on the maize yield

Location	Percentage of maize yield in intercropping based system and control (%)					
	Stylo weed	Vine legume	Velvet bean	Ground nut	Soy-bean	Cow-pea
Suối Giàng, Văn Chấn, Yên Bái	12	11	10			
Mường Sang, Mai Sơn, Sơn La		6				
Chiềng Chăn, Mai Sơn, Sơn La		18				7
Chiềng Hắc, Mộc Châu, Sơn La	7	2	3			
Phiêng Luông, Mộc Châu, Sơn La				9	10	
Giang Ma, Tam Đường, Lai Châu		7				
Bản Bo, Tam Đường, Lai Châu						22
Average	**9.5**	**9.1**	**6.5**	**9**	**10**	**7**

3.2.3. Implementing growing season 2 after harvesting season 1

Similar to intercropping, having season 2 aims to produce and manage covering materials more properly, and increase income for farmers. In Yen Bais, there are two maize growing seasons on the large scale, this practice experiment and promotion only conducted in Lai Chau and Son La. Crops that can be grown 2 seasons per year recommended include maize, cowpea (Vigna cylindrica), mungbean, soybean, groundnut and oat (Avena sativa) (Table 4).

The results indicated that among these crops, maize and oat are found to produce greatest biomass. Oat is drought resistant and regarded as relevant winter crop in the climate condition in Chieng Hac, Moc Chau, Son La. Biomass yield of oat is 3.5-4 tons/ha. Aside from covering materials, this provides food source for cattle in winter.

Table 4: Season 2 crops selected for experimented and extended

Study site	Season 2 crop
Mường Sang, Mai Sơn, Sơn La	Cowpea, mungbena, soybean
Chiềng Chăn, Mai Sơn, Sơn La	Cowpea, mungbena, soybean
Chiềng Hắc, Mộc Châu, Sơn La	Oat
Phiêng Luông, Mộc Châu, Sơn La	Soybean
Bản Bo, Tam Đường, Lai Châu	Maize, soybean, groundnut

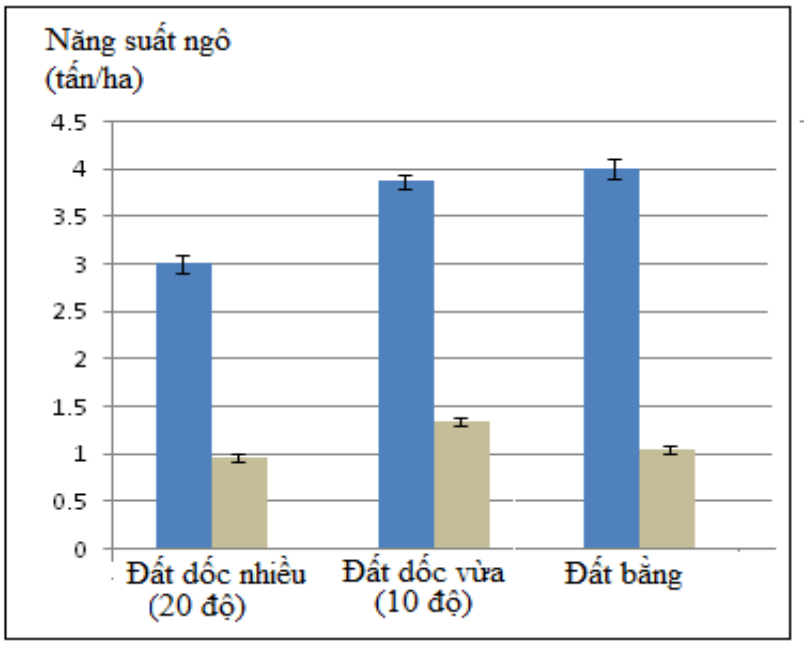

Figure 5: Maize yield (variety CP333) and intercropping crops (soybean, variety DT 08) in season 2 in Ban Bo, Tam Duong, Lai Chau

In Ban Bo, the season 2 maize has growth capacity and yield similar season 1 (Figure 5). In addition, the season 2 maize plant also produce significant biomass, about 3-5 tons/ha. If receiving proper management and pest control, groundnut, cowpea, mungbean and soybean yielded 1.3-2 tons/ha, however, biomass produced by these crops is not significant.

The most difficulty for the northwest farmers to develop second season is the supply of seed materials (maize, groundnut, soybean, cowpea, and groundnut), short growing period, and drought resistance, well adapted with local climate. In addition, experience in organising cropping season and timing is required. In the unpredictable climate change, the rainy season begins and ends irregularly, the determination of sewing and/or planting time, and varieties for significant yield in both two seasons becomes a big challenge.

3.2.4. Preparation of small terraced field to grow maize

On the sloping areas, terrace was built from the bottom upwards, following the contour lines. The distance between two consecutive steps equals the distance between two maize lines (60-70 cm). Width of step is about 30 cm, enough space for one maize line (Figure 6).

The observed results indicated that in both cases, with or without covering, small terrace was found to contribute to the increase yield significantly (Figure 7). However, the biggest constraint is high labour cost spending for design and fix the terrace in the first 1-3 years. As estimated by farmers, with farmer practice (control), the required labour is 62-68 days/ha throughout the season. With small contour, it required 90 working days in the first year, if incorporating with covering the land, total labour required is more than 100 working days.

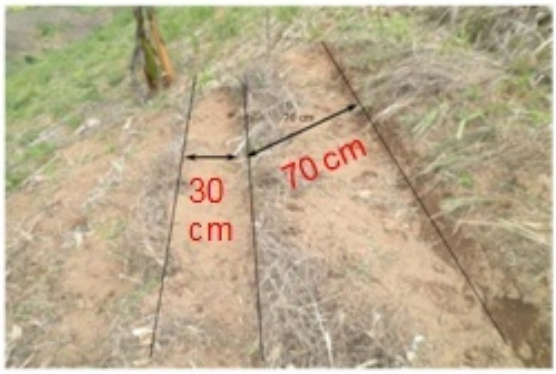

Figure 6: preparing small terraced fields on sloping land

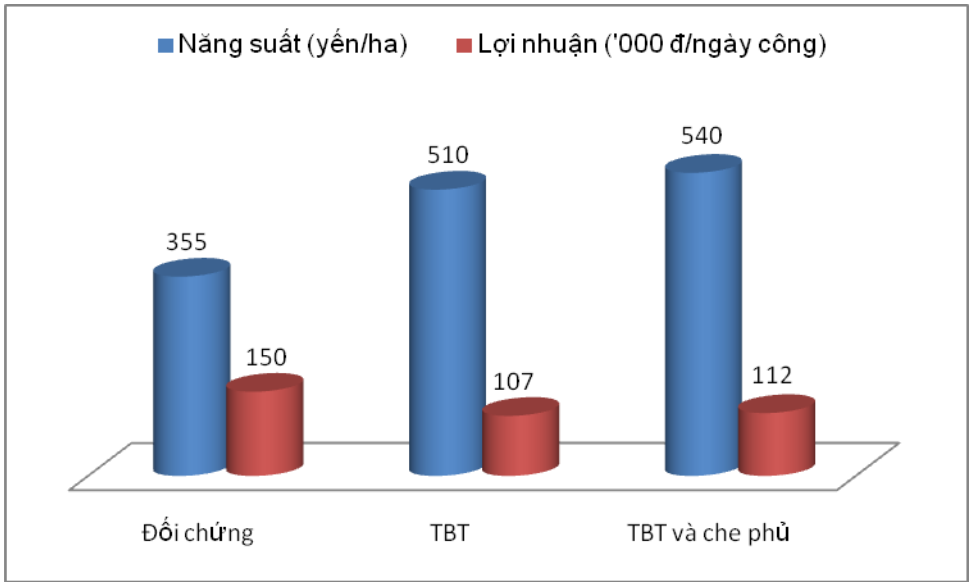

Figure 7. Yield and benefit per working day in the study site in na ot commune, Mai Son district, Son La province (2010, LVN10 variety)

The use of small contour in the first years, due to high labour cost, benefit counted per working day cost significantly declined compared to control (Figure 7). In the northwest, where the labour resource becomes less available during cropping seasons, this is the biggest constraint in experiencing this practice. In reality, in 2014, no householders applied this practice.

3.2.5. Intercropping the crops for cattle in the contour lines

Intercropping with weed in the contour in the maize field aims to reduce soil erosion and produce food source for cattle, minimising freely grazing. This technique was experimented in Giang Ma commune, Tam Duong province, Lai Chau, using Guatemale weed.

The result showed that growth and yield of maize have not been effected by weed. Whereas Guatemala produces large fresh biomass, about 5 tons/year in the first year, and higher than following years. The first harvest would be expected after 60 days, thereafter every 38-45 days for each harvest. During 12 months to 2 years after, due to dry and cold weather, the duration between harvests increased and yield per each harvest was lower.

Hình 8: Growing, management, harvesting and using weed to feed cattle

According to farmers' records, growing Guatelama weed could reduce erosion, provide food source for cattle. 'Regardless of maize yield reduced, I still prefer to intercropping maize with weed, as its benefit toward cattle'. This is a comment of a farmer in Giang Ma, Tam Duong, Lai Chau.

The biggest difficulty for the northwest farmers in applying this practice is to invest on planting, management and harvesting labour. The transportation of weed from field to the places to feed cattle is also labour cost, and facing difficulty, especially fields located far away. Particularly, with householders do not own cattle, the labour cost and investment spending for management this crop is a constraint.

4. Conclusions

Based on the above results, the following conclusions were drawn:

- Strengthen farmer, community leaders participatory and local extension network in research, design, evaluation, demonstration and adjustment the technical packages is an effective solution to promote adoption of land use practice in maize production in areas as major crop in the northwest. Particularly, the integration of extension programs in province and district levels, assist fermers financially and provide technical guide in order to overcome constraints and to approach and apply these practices. Using participatory approach, application of the practices have been continued extending after ADAM and northwest project completed.
- Selection of practices used to extend depended on the locals, geographic, soil, climate and investment capacity of householders. Among 5 practices as subjects of this study, land covering, minimum tillage and intercropping with legume crops have been most selected in Son La, Yen Bai. While in Lai Chau, developing season 2 has been applied readily.

- A major constraint preventing household farmers in the northwest from applying all 5 practices is the increase in labour cost in the beginning years of application. Other constraints relate to producing and managing covering materials, pest and rodent management, markets for intercropping crops.

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