On-farm participatory research for development of integrated management of bamboo plantations in Northern mountainous areas of Vietnam

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Abstract

Development of luong bamboo (*Dendrocalamus barbatus)* plantations, with more productive and sustainable practices, promises solution to address both problems of poverty and soil erosion currently faced by a major part of the population of several districts of Northern mountainous areas of Vietnam. In Thanh Hoa Province, were about 55 000 ha of luong represents the major source of income of a large part of the inhabitants, 50% of the population, mainly ethnics, is still leaving beyond the poverty line. They are also facing a major problem of widespread soil degradation. Despite farmers are concerned by soil erosion and environmental sustainability, it is not a driving force in their adoption of new practices and they keep on looking for strategies allowing a quick improvement of their incomes.

Lessons from experience outlined the relevance of a participatory research approach to define and disseminate new technologies allowing farmers to get high income while ensuring environment sustainability. The On-Farm-Research (OFR) experimental design, implemented to test and develop more sustainable intercropping systems in new luong plantations, showed the relevance and efficiency of this approach. It also demonstrated the importance of a large scale action to get a good understanding of the array of constraints hindering farmers' strategies and ensure a broad-adoption of best-practices.

This communication deals with the main lessons drawn from these 3 years of on-farm-research and extension work on intercropping in new luong plantations, from both technical and methodological point of views. It makes recommendations on the best practices to be promoted, but also shows the difficulty to implement on farm research and promote bamboo plantations despite its many interests.

Last it gives some recommendations on the way to ensure the transfer of capacities to local actors in order to ensure a long-term agricultural development by defining by themselves the technologies addressing the changing range of constraints they are facing.

Key words: on farm research, intercrops, bamboo, *Dendrocalamus barbatus*, groundnut, participatory planning, sustainable development

Introduction

Luong bamboo: a major source of income and a way to reduce soil erosion

Thanh Hoa province, located 150-200 km South-West of Hanoi, is one of the poorest provinces of Vietnam. According to the official list of the 61 poorest districts (61/640)[1], seven districts of this province are belonging to the 10% of poorest districts of the country. In these mountainous districts, mainly inhabited by ethnic minorities (Muong, Thai), poverty rate is higher than 50%, with a poverty line of 200,000 VND/month/person (1 USD= 17 500 VND). The livelihood of these smallholders is based on mixed farming (lowland rice, short term crops such as cassava, sugarcane and maize on slopes, small livestock farming, bamboo plantations and forests) and relies on a large extent on a giant Bamboo (*Dendrocalamus barbatus*, locally known as Luong) plantations. Most of them grow bamboo as a "living bank", providing regular and safe income available at any time. With about 55 000 ha, North-West Thanh Hoa is the main production zone for *luong bamboo* in Vietnam (about 50% of surfaces over the country). Every year, in North-West Thanh Hoa, about 20-25 millions of luong culms are harvested (more than 550 000T/year). Luong good mechanical properties and big size allow a wide range of utilizations, such as construction, dykes reinforcement, paper pulp, and production of chopsticks, flooring, panel boards and handicraft (Gret 2008).

In Vietnam 75% of the total land area is hilly or mountainous, with a large part (about 35%) suffering from various degrees of water erosion or fertility decline (Thai Phien et al. 2002), after several years of short term intercrops grown with unsustainable practices generating high rate of soil erosion (cassava, sugarcane, maize, etc…). Upland soils, especially steep slopes, are highly prone to quick soil erosion and depletion, due to their light texture, low organic matter and low levels of nutrients (Howeler 2002; Thai Phien et al. 2002; Storey n.d.). These soils, once they are bare (or only partially protected by low vegetal cover), are very sensitive to run-off (Podwojewski et al. 2008; Valentin et al. 2008; Orange et al. 2007), especially in areas like Thanh Hoa, where heavy rainfalls and storms occur in a short period (May to September). Thanks to "its extensive fibrous roots system, the leafy mulch it may produce on the soil surface, its comparatively dense foliage which protects soil against beating rains, and its habit of producing new culms from underground rhizomes which allows harvesting without disturbing the soil" (Zhou et al. 2005) bamboo is favored for its ability to reduce run-off and fertility loss (Kleinhenz et al. 2001; Farelly 1984; Storey n.d.). Planting *luong* is therefore a sustainable source of incomes for smallholders, having positive environmental impact and bringing sustainable incomes.

Main limitations to luong planting

In the 70's and 80's, government local agencies were widely involved in the support and incentive to the augmentation of surfaces dedicated to luong plantation. Most of the researches on luong plantation and management practices were conducted in the 70's (PI, 2008) and only few were carried out afterwards (PI 2008, Nguyen Hoan Nghia 2005). However, researches on bamboos of Vietnam were not totally completed for a field or species at a period of time, but various and scattered in different units and regions, so that this makes it difficult for people to follow and apply (PI 2008). Moreover, except some technical procedures edited by extension services, like "The Technical procedure to plant Luong" (MARD 2000), few actions are currently carried out by government agencies promoting luong sustainable development. It results in difficulties for developing luong compared with crops more integrated to the market through

agro-industries companies (sugarcane, cassava, maize but also acacia for paper). Indeed, such companies provide active and strong incentives to farmers (technical advices, advances for inputs…). These difficulties are reinforced by the lack of income during the early years of luong plantations, as one has to wait 5 to 7 years before the first harvest.

Main principles and objectives of project action

To tackle these issues, identify and transfer to farmers best practices for luong planting and management, in 2005, Research and Technological Exchanges Group (Gret) started to locally assess and select a comprehensive set of practices, from luong planting to harvest management (planting density, quality of seedlings, season of plantation, intercropping in early years, fertilization of newly planted and mature plantation, rehabilitation of degraded plantations, harvest management), before running activities to disseminate the best practices. Most of the tested techniques will not show significant results before one or two more years. However, trials on intercropping newly planted bamboo with other crops, launched in 2006, already provided interesting results.

These activities are part of the comprehensive set of actions implemented by Gret to develop and structure the local bamboo value-chain and to improve the positioning and income of small-holders. One component focuses on farmers and resources, through the support to the development of homestead nurseries and new plantations, the implementation of trials and demonstrations on planting and sustainable forest management, the support to farmers' organizations and creation of links with enterprises and markets. Other activities are related to the support to bamboo supply chain down stream: facilitate exchange between supply chain stakeholders, build capacities of entrepreneurs, support small and medium enterprises, support marketing, relations with investors, and tests for diversification of production. Some complementary activities were related to sector enabling environment: discussion with local government on problems and solutions for smallholders and bamboo processing entrepreneurs, multi-actors discussions and seminars, capacity building of local actors, organization of meetings and visits, exchanges with external actors on bamboo.

This communication deals with the main lessons drawn from these 3 years of on-farm research and extension work on intercropping in new luong plantations, from both technical and methodological point of views. It makes recommendations on the best practices to be promoted, but also shows the difficulty to implement on-farm research and promote bamboo plantations despite its many interests. Thus, it shows how long sustainable practices promotion can be hindered by smallholders' short term agendas and specific financial and social constraints, and need a comprehensive approach to ensure a sound long-term development.

Project Methodology

On-Farm-Research and Participatory Research

OFR is a research model based on a cooperative effort (between researchers, technicians and farmers) targeting the identification, development or adaptation, and use of technologies specifically tailored to meet farmers' needs and constraints.

Main principles of OFR and Participatory Research

The concept of Participatory and On-Farm Research initially attained wide-scale use in the 70's by researchers and agronomists, as a response to the failure of top-down Transfer-of-Technology model. Technology packages developed under controlled conditions of research stations failed to meet resource-poor farmers' needs and means (for example they were requesting more inputs that what farmers could afford, were not taking into account farmwork planning,...) and where not broadly adopted. Participatory approach is primarily based on the assumption that agricultural technology must emerge from the farmers' needs as they co-identify them. It underlies the need to consider farms as complex systems composed by an array of interrelated matters (technical, environmental, institutional , social and economic) which hinder farmers strategies and practices (Selener n.d.) to define technologies which can be effectively adopted by farmers and benefit to the farm as a whole.

This OFR process is based on innovation co-construction, through:

1. Introduction of technical innovations which are locally not yet found on steep slopes (new crops and/or new tending practices);
2. Adjustment of techniques and extension method to the variability of the local conditions (different types of soil, slopes, etc) and to the farmers' means and constraints;
3. Improvement of dialog and confidence between farmers and agronomists;
4. Dissemination (or extension) of these practices from Farmers' Fields' Schools.

Farmers do not only provide land and labour, they are also involved in the selection, monitoring and evaluation of the tested technologies. OFR involves several levels of control and management exercised by farmers and researchers (from Researcher-Managed OFR to Farmers-Participatory OFR). Rhoades (1982) defined four stages in which farmers could be more or less involved: 1) Definitions of problems to be solved; 2) Research of possible solutions; 3) Experimentations of these solutions; 4) Assessment of the results. The method adopted here sought a participation of farmers in all stages. Indeed success of Participatory Research is embedded in the quality and steadiness of exchanges between farmers and researchers. The local anchorage of the project agronomists and technicians (who are living in the countryside, in two traditional houses located at less than 1 hour from all trial fields) is one key of its intervention success.

A participatory definition of problems and planning

Participatory Rural Appraisals were organized in each communes of action and identified the lack of income during the early years preceding the first harvest (usually done 5 to 7 years after planting) as a main constraint preventing farmers from planting luong (together with the competition with other crops and tree species providing higher income on the short and medium run while getting incentives from agro-industries companies). It also outlined that farmers are used to intercrop newly planted luong with short-term intercrops providing high income with techniques having negative impact on both soil fertility and luong growth. Prior to project action, there was no specific research or technical advice for farmers regarding these issues.

Then, focus groups were organized in 3 communes to select crops improving erosion control while ensuring short-term income. Farmers and agronomists discussed the negative impact of cassava, sugarcane and maize on both soil fertility and bamboo growth due to unsustainable practices (no or low mineral fertilisation, no cover crop). They also debated the possible interest of replacing them by other short-term crops: groundnut, soybean, mongo bean and sesame. Indeed these crops and more especially groundnut were proved to have better impact on soil

erosion thanks to faster-developing and wider vegetal cover (Steiner 1985, Putthacharoen et al. 1998, Thai Phien et al. 2002). Legumes were also expected to increase the quantity of N available in the soil for luong while not much competing with it for light, water and other nutrients (thanks to a low spatial competition of foliage and roots systems between the two crops).

Farmers who were interested in running trials were registered and involved in trials design and implementation. They were provided with technical and financial support from project and had to respect one specific crop management sequence, to ensure a homogenous experimental design. Financial support (initially project covered 50% of expenses) was provided to allow poorest farmers to get involved in trials and follow agreed crop management sequence. Such financial support is also often necessary to encourage farmers to shift from cultivation of crops for which they get advances on inputs from agro-processing factories. Other farmers registered to get seeds and technical support and test these crops on "demonstration plots". For these "demonstration plots" there were no fixed operational sequence and part of the plots was monitored to provide "transitional results" on operational sequences less extensive than in trials (as farmers applied lower density and less fertilizer). Last, several farmers decided to keep growing the same intercrop than usually (cassava, maize, sugarcane) and their results were monitored too as "reference crops".

A strong technical support

Farmers were provided with a strong and steadiness technical support through:

1. One-Day Farmers' Field Schools (half day dedicated to theory, half day for practicing in field) organised at hamlet and village scale on intercropping practices (for each crop : sowing date, fertilization, planting density, tending practices, pest management);
2. In 2008, two technical leaflets[2]: (addressing groundnut and soybean intercropped with luong) were printed to be used as a technical reminder for trained farmers (as farmers are not used to take notes during trainings) and to facilitate dissemination of sustainable practices;
3. Regular visits of technicians providing farmers opportunities to discuss and solve agronomic problems likely to reduce yields (pest, diseases, unsuitable practices, etc…).

A joint evaluation of results

A particular attention was paid to allow a common evaluation of trials results, involving farmers, local authorities and agriculture services. Two types of restitution seminars were organised a few days before harvest:

- One-Day Seminars were organised in each village. They gathered farmers involved in trials on short-term intercrops but also those benefiting from project support for luong new plantations, village leaders and project collaborators.
- One-Day specific Seminar was organised in one commune (gathering most of project trials) in which were also invited commune and district authorities and representatives of agricultural extension services.

These seminars gave stakeholders the opportunity to visit trials ran in the commune, to discuss results presented by project technicians and to make proposals for the following cropping seasons (which new crop or techniques to be tested? Where? ...). In addition to these seminars, project organised visits for farmers and local authorities from other projects (Hadeva in Phu Tho, Gret project in Houa Phan Laos). These projects working on luong plantations were planning to test, promote or support short-term intercrops in new luong plantations. They visited trials and demonstration plots and met some farmers growing short-term intercrops in their new luong plantations.

An iterative process

Five series of trials and demonstration plots on short-term intercrops were run from spring 2006 to autumn 2008 (Table 1). Running trials during several seasons and in different locations is essential to assess both agronomic and economic results under variable annual climatic and market conditions while promoting wide-scale extension. It was also the opportunity to regularly refine trials through an iterative assessment process: after each harvest, farmers where invited to discuss the results. Crops selection evolved according to results, to confirm the suitable crops and replace unsuitable ones. In 2007, following good yields obtained for groundnut, farmers decided to test new cultivars (L14 and L20) purchased by project in other provinces. These improved varieties were expected to provide higher yield than "local" variety. At the end of the second phase, farmers decided to test mixed intercrops (luong + groundnut + cassava, luong + groundnut + maize). They target win-win strategies: gain profit from positive impact of groundnut on soil and additional income from cassava or maize, while reducing economic risk (diversification).

Project support method evolved too (Table 1). In 2008, to avoid some problems met during previous year (some farmers were not able to purchase enough fertilizer or to spend enough labour due to family problems) it was decided to increase the financial support of farmers running trials to cover 100% of the expenses. To improve the homogeneity of the experimental design, it was also decided to reduce the number or farmers involved in trials and do several replications on each plot. Indeed, soil condition can drastically change from one plot to another one (due to cropping history, slope...) and even within one plot (soil fertility being usually lower on the top of slopes than on the base). Doing several replications in one plot allowed to reduce this variability.

Table 1 : main evolution of trials objectives, scale, assessment and reorientation:

Project phase	*Objective*	*Trial scale*	*Results of participatory assessment*	*Reorientation*
LDP 1st phase (spring 2006)	Compare: - Food and industrial short-term crops (groundnut, taro), - Spice and medicine crops (kudzu, ginger) - tephrosia hedgerows)	-12 trials, - On 5 species, - In 3 communes. - 1 district (Ngoc Lac)	- Kudzu and taro not suitable - Groundnut, Ginger and tephrosia suitable	- Keep on assessing groundnut and tephrosia - Test other crops (soybean, mongo bean and sesame) in both spring and autumn seasons
LDP Interim phase (spring-autumn 2007)	Compare: -"Reference" crops (cassava, maize, sugarcane) - Groundnut, soybean and sesame; - Keep on assessing tephrosia	- In 5 communes - In 2 districts (Ngoc Lac, Thuong Xuan); - 83 households (for trials, demonstration and reference crops) - 105 *sao** (5.25 ha)	- Groundnut ensure the best agro-economic results; - Cassava and sugarcane keep arising farmers interest	- Keep running trials on groundnut, soybean and sesame - Run trials on mixed intercrops (groundnut + cassava, groundnut + maize).
LDP 2d phase (spring-autumn 2008)	- Keep on running trials on legumes and sesame. - More trials on groundnut as previous trials outlined its agronomic and economic interest. -Introduce and test 2 new cultivars L14 and L20 - Less trials (but replications)	- In 9 communes; - In 4 districts**; - Results monitored for: 45 Households; 95 plots	- Groundnut ensure the best agro-economic results; - L14 is the most suitable variety; - Mixed intercrops showed good results	- No more trials but support for seeds for "demonstration plots" - more demonstration plots on groundnut with new practices (high density, early sowing) - keep testing mixed intercrop

* 1 sao = 500m²

** Project activities extended to 2 new districts (Ba Thuoc and Quan Hoa), located in the north-western part of Thanh Hoa province.

Extension Work

As explained above, seeds and technical support were provided to a larger number of farmers who were not involved in a formal OFR. Such "demonstration plots" were expected to promote a wider and more sustainable adoption of the appropriate techniques. Crops and technical trainings were achieved together with OFR similar activities. Support for seeds was limited to 2 *sao*/household (0.1 ha), in order to maximise number of beneficiaries. From spring 2008, project decided to provide its support through the establishment of seeds banks. Seeds were provided to farmers as a loan to be reimbursed right after harvest. Then seeds were borrowed to other farmers for the following cropping season. That way, seeds banks were expected to expand and sustain the dissemination of crops (especially groundnut): demonstration plots outline the agronomic and economic interests of these crops, while seed banks encourage more farmers to try such model on their own plots (by reducing investment costs). They also gave access to more farmers to new cultivars not locally available (L14 and L20). More than 400 families grew groundnut on about 30 ha of new luong plantation during this project's stage. More than 90 families grew soybean on 10 ha. About 50 km of Tephrosia were also planted as contour line and hedgerows.

Description of project achievements

Trials results

Outcomes expected form crops (legumes and sesame) tested by farmers were threefold:

1. Provide a short term income similar or higher than crops traditionally intercropped with newly planted luong (cassava, maize, sugarcane);
2. Limit the soil erosion occurring on local steep slopes and increased by crops usually selected;
3. Promote luong growth, instead of competing with it, to ensure a faster development and allow earlier first harvest.

Results presented here were discussed with and agreed by both farmers and local authorities

Agro-economic results (Vogel 2007, 2008)

The main result drawn from this OFR is that groundnut is the most suitable crop to be intercropped with newly planted luong on steep slopes within this locality.

Table 2 : Yield of crops monitored in 2007 and 2008

T/ha	*Spring 2007*	*Autumn 2007*	*Spring 2008*	*Autumn 2008*	***Average***
Groundnut[1)]	2.8	1.1	1.9	1.1	1.7
Soybean[2)]	0.9	1.0	1.9	0.6	1.1
Sesame[2)]	0.4	0.3	0.4	0.3	0.3
Fresh cassava	52.3		16.5[4)]		34.4
Dry cassava	18.5		8.1		13.3
Sugarcane[3)]	64.8		41.2		53
Maize	2.7	1.4	N.D.	1.8	2.0

[1)]Yield of dry pods (as farmers are used to sell this crop); [2)]Yield of dry seeds (as farmers are used to sell this crop); [3)]Mean for a 3 years' cycle; [4)]Contrary to legumes and sesame, yields of cassava, maize and sugarcane were not monitored on the same plots in 2007 and 2008, so variation may not be linked to climate variations or cropping sequences;

Groundnut is well adapted to local conditions and is not much sensitive to diseases and climatic disturbances. Yields (Table 2) are close from those quoted by Thanh Hoa local Agriculture office[3] (2.4 T/ha in 2007). Yields were lower in 2008 due to the exceptional bad weather which occurred in winter and delayed the two cropping cycles. Groundnut ensures high incomes (more than 30 millions VND/ha/year) (Table 3). Trials also outlined that groundnut got higher results when sown before the 5th of March with a high density (more than 20 plants/m²). However, groundnut is sensitive to shadow, so that it should not be grown once luong vegetative cover is well developed (2 to 3 years-old plantations). Last, the variety L14, introduced in the area by the project, ensured the best yield and income in this area (compared with local variety, and another variety introduced by project L20).

Soybean has a good potential on slope (1.7T/ha[4] for a Net Income of 15 millions VND/ha) but should be proposed on good land and with intensive care only. Average yields obtained were lower than 600kg/ha (Table 2), leading to a negative net income average (main expenses being for fertilizers supported by project). Indeed, this crop is sensitive to soil and weather conditions and to pests and diseases regularly occurring on steep slopes, where farmers are not used or able to provide intensive cares.

Sesame mean yield was 300kg/ha (Table 2), and several households got low yields due to heavy rainfalls at sowing and/or flowering time. They got Net Income almost nil (main source of expenses being fertilizers). Nevertheless, sesame also provided good yields (600kg/ha, net income =11.5 millions VND/ha) when these two growing stages were not affected by rain.

Table 3 : Economic results of the most interesting crops monitored in 2007 and 2008

			Spring 2007	*Autumn 2007*	*Spring 2008*	*Autumn 2008*	***Annual Average***
Groundnut	NI[1)]	1000VND/ha	22 860	18 564	12 608[4)]	16 780	**35 406**
	ROI[2)]	%	4.6	5.5	1.0	2.0	3.3
	NI/ FLD[3)]	VND/day	95 250	77 350	26 913	47 026	61 635
Fresh cassava	NI	1000VND/ha	40 562		5 212		**22 887**
	ROI	%	30.9		1,7		16
	NI/ FLD	VND/day	126 757		44 962		85 859
Dry Cassava	NI	1000VND/ha	44 853		8 030		**26 442**
	ROI	%	34.2		3		18
	NI/ FLD	VND/day	131 922		10 037		70 979
Sugarcane	NI	1000VND/ha	6 193		10 762		**8 477**
	ROI	%	0.4		0.5		0.5
	NI/ FLD	VND/day	47 467		204 637		126 052
Maize	NI	1000VND/ha	6 162	2 840	ND	3 363	**9 002**
	ROI	%	5.9	2.3	ND	1.7	3
	NI/ FLD	VND/day	32 434	21 850	ND	46 364	33 549

[1)] NI = Net Income; [2)] ROI = Return on Investment = Net Income/ Total expenses; [3)] NI/LD = Net Income/Family Labour Days; [4)] Groundnut pods sale price is higher in autumn than in spring. Yields obtained in spring 2008 were higher than in autumn but due to winter bad climatic conditions, production quality was lower and farmers got lower price.

In 2007, **cassava** prices benefited from a 50% increase (Table 4), allowing a high economic interest (more than 30 millions VND/ha for fresh pods for a high yield of about 50T/ha) and encouraging farmers to grow cassava on larger surfaces in 2008. Nevertheless, international market fluctuations led to a drop in prices, which were reduced by half. Net Income (Table 3) drastically decreased (about 10 millions per ha, for a yield of less than 20T/ha).

Table 4 : Main evolutions of cassava price from 2006 to 2009

Price (VND/kg)	*December 2006-January 2007*	*December 2007-January 2008*	*December 2008*	*January 2009*
Fresh cassava	400	800	500	350
Dry cassava	1500	2500	1500	1300

Net Income from sugarcane (Table 3) remains lower than the one obtained for cassava and groundnut and provides a low Return on Investment (less than half of invested amount) as amount of inputs (for fertilizers and labour) is high. Moreover, harvest is very restrictive: date of this time-consuming activity is fixed by the factory and may compete with other farm activities (like rice transplanting, groundnut sowing…).

To a lesser extent, maize is also traditionally intercropped with newly planted luong. In most of the communes of project intervention, maize is grown in a very extensive way with low inputs, leading to low and variable Net Income (except in Cao Ngoc where it is widely grown[5] due to the establishment of a maize processing company facilitating access to fertilizers). However, project did not monitor enough plots and there was a too great variability among results to draw any firm conclusion on agro-economic results of maize intercropped with luong on steep slopes. A last crop locally intercropped with luong was upland rainfed rice. Nevertheless, it was identified in few places only and was not monitored by project.

Impact on soil erosion

In Thanh Hoa Province, 2/3 of the territory is covered by hills and mountains. These soils are highly prone to erosion, especially when they are bare, due to a light structure, a low depth and low level of organic matter, especially when short-term crops were grown with unsustainable practices (no or inappropriate mineral fertilisation, no cover crop...) during several years (Tran Dinh Tro 2001, Valentin et. al 2008). Heavy rainfalls occurring in the area (1800 mm/year, concentrated in few months, from April to July) are also an aggravating factor. Mature luông plantations allow to reduce soil erosion (thanks to high roots and vegetative covers), but not the newly planted ones (4-5 first years). Intercrop can partially solve this problem if suitable crops and practices are selected. OFR trials were run to assess the impact of different intercrops on soil erosion in less than 1 year-old luong plantations.

Table 5 : Main results of trials on impact of several cropping associations on soil erosion

Cropping associations	*Spring 2007*				*Spring 2008*			
	Time	Pp (mm)	Eroded soil (kg/ha)	%	Time	Pp (mm)	Eroded soil (kg/ha)	
Bamboo + Mongo bean + Soybean	18/06/07-06/08/07	297.3	48.6	17.3				
Bamboo + Cassava			107.8	38.4				
Bamboo+ Sugarcane			280.4	100				
Bamboo + Groundnut					25/05/08-10/06/08	147	171.2	33.1
Bamboo + Soybean							370.4	71.5
Bamboo + Maize							518	100

In spring 2007, trials showed that the amount of eroded soil with luong intercropped with legumes was only 20 % compares with luong intercropped with sugarcane and 50% lower than with luong intercropped with cassava. Trials ran in spring 2008 showed that run-off when intercropped with groundnut was only 33% of the one observed with maize, while soybean was 71.5% (Table 5). However, as soybean was harvested earlier and not immediately followed by another crop, soil erosion drastically increased after harvest. These results should be used as a rough guide only. Indeed these trials on soil erosion, done in short period (less than 3 months) without repetition were done for a demonstrative purpose rather than a scientific one. However, they corroborate other trials ran on more scientific bases in other North Vietnam hilly area ((Nguyen The Dang et al.; Thai Phien et al. 2002) and other parts of South Asia. For example, trials ran in Thailand showed that cassava grown for root production caused more than twice as much dry soil loss by erosion as mungbean, and three times more than maize, sorghum, groundnut and pineapple (Putthacharoen et al. 1998).

Other practices were also tested by farmers with project support, but results were not monitored or did not allow to draw any firm conclusions (not enough samples, too much variability). *Tephrosia candida* seeds were provided to be planted between luong lines. This two-years-cycle legume is commonly known for reducing soil erosion and improving soil when its residues are returned to soil. Trials run in Vietnam North Provinces (Nguyen The Dang 2002) showed that "*when hedgerows of tephrosia candida and/or vetiver grass were added, erosion declined to only 40-49% of reference treatment*[6]". From spring 2008, farmers also started to test mixed intercropping (groundnut + cassava, groundnut + maize, groundnut + sugarcane) in their new luong plantations. Such cropping systems are already commonly grown on lowlands (without luong) but not on slopes. Farmers were satisfied by results, especially for groundnut +cassava.

Further researches should be done on soil erosion reduction. Other practices showed good results in other provinces. For example, Thai phien (2002) reported that the combination of these two measures (Intercropping cassava with legumes and *tephrosia candida* hedgerows) *"improves soil fertility, resulting in higher yields of cassava and intercropped legumes as compared to the control treatment without hedgerows"*. Moreover, except one farmer who grew groundnut during 3 cycles (spring, autumn, winter) and who get low yield, slopes are left fallow during winter and are more exposed to run-off. More work could be done to identify a cropping system ensuring a proper soil cover through the year. Studies were already carried out in other hilly areas of North Vietnam on cover crops (Affholder et al. 2008). However, although farmers are concerned by soil erosion and environmental sustainability, it is not a driving force in their adoption of new practices. They are first looking for strategies allowing a quick improvement of their incomes (Orange et al. 2008).

Impact on luong growth

Two series of trials were run to assess the impact of different crops on luong growth. Best luong survival rates were obtained with groundnut, while the worst one was observed for luong intercropped with cassava. More shoots were obtained with legumes and sesame. Biggest shoots were observed for clumps intercropped with soybean while clumps intercropped with sugarcane produced the highest shoots. Worst results were obtained with cassava (Table 6). The second series of trial confirmed the negative impact of cassava on luong growth: luong produce smaller and weaker shoots when grown close to cassava. Nevertheless by applying a distance of more than 1m between luong and cassava plants this negative impact was reduced. Mixed plantations of acacia (*keo*), luong and cassava gave the worst growth for all crops.

Table 6 : Results of trials on impact of several intercrops on luong growth

Treatments (Year 2007)	*Bamboo Survival rate (%)*		*Number of shoots/clump*		*Shoots diameter (cm)*		*Shoot height (m)*	
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Bamboo + Groundnut	95,9	97,2	2,1	4,3	1,1	1,4	1,7	1,9
Bamboo + Soybean	94,5	94,5	2,3	4,1	2,1	2,4	1,5	2,4
Bamboo + Mongo bean	94,5	94,5	2,2	0,0	1,9	0,0	1,7	0,0
Bamboo + Sesame	94,7	94,7	2,1	3,7	1,5	2,2	1,7	2,3
Bamboo +Cassava	57,5	53,5	0,3	0,6	1,4	1,1	1,1	1,7
Bamboo + Maize	85,3	85,3	1,7	2,7	1,4	2,3	1,3	1,9
Bamboo + sugarcane	94,3	91,3	1,4	2,4	0,9	1,3	2,0	3,0

Negative impact of cassava, sugarcane and maize on young luong is mainly explained by competition for light and nutrients (as their canopy is higher and their roots system more developed). This impact is limited in sugarcane fields due to the high rate of fertilizers applied. Nevertheless, it has been observed that the burning of sugarcane residues after harvest and trucks may dramatically damage bamboo shoots and leaves. On the contrary, legumes do not compete with luong for light and competition for nutrients and water is limited, while reducing soil erosion and improving soil fertility. Luong develops more and bigger shoots and can be harvested earlier.
Two years after plantation, demonstration plots implemented in Kien Tho (by the *green hill* farmers' group) showed marked differences in luong clumps development with different intercrops. Luong intercropped for 2 years (4 cropping seasons) with legumes, and more especially groundnut, showed a development close from the one usually observed for 4 to 5 years-old luong planted in traditional way, while luong intercropped with sugarcane and maize showed a slow development.

Discussion on the main lessons drawn from experience

Running trials through OFR research was expected to provide accurate results on agro-economic potential results of different intercrops while initiating the spreading of the intercrops identified by farmers as the most suitable ones.

Scientific value of OFR

The statistical rigour of results obtained through OFR can't be the same as for agronomical trials run in station. For statistically significant information on crops (like impact of several techniques on yield and income, comparison of several cops…) a larger number of plots is requested to have enough replications of different cropping systems and/or treatments and conduct variance analysis. With OFR, it is difficult to set a large experimental design of plots with similar soil conditions, as farmers are smallholders with specific soil conditions (various locations, cropping history...). Then, even with financial support, farmers tend to adapt recommended techniques to their means, working calendar (trials barely coming first) and most of all, short-term strategy (leading them, for example, to reduce time invested for one crop showing low development to limit financial risks). Such modification in operational sequence make analysis and comparison more complicated. Moreover, trials are highly time consuming and request skills (for monitoring, data capture and analysis). It limits the number of crops and techniques which could be successfully tested and monitored by project. As a consequence, it was not possible to get all the statistically significant data initially expected, more especially regarding mixed intercropping in luong plantations.

However, the statistical rigour of results obtained on research station often failed to ensure their broad-adoption. OFR has another scientific dimension based on a systemic perspective essential to tackle the complexity of farmers' real constraints. The assessment of real potential of a technical innovation is inseparable form the understanding of the array of constraints hindering farmers' strategies. As outlined by Chambers et Al. (1985), "the criterion of excellence is not the rigor of an on-station or in-laboratory research, or yields in research station or resource-rich farmer conditions, but the more rigorous test of whether new practices spread among the resource-poor".

Factors behind Best-Practices Wide-Scale Adoption

This 5-seasons experience was the opportunity for technicians and farmers to define test and compare several intercropping systems. Being involved at each step of the research process allows farmers to identify and select practices adapted to their needs and means. The most compelling proof is the adoption of the most suitable practices (groundnut, groundnut + maize or cassava) by most of the farmers who tested it during the following cropping seasons, until luong was too much developed to ensure a proper growth of groundnut (2-3 years after luong plantation). Moreover, in each commune, the number of people interested in intercropping groundnut with newly planted luong increased after one year of OFR and extension work. In any communes where LDP carried out activities on intercrops, some farmers[7] started to grow legumes (mostly groundnut) on their slopes and/or luong new plantations, without project support. Most of them started after observing results of their neighbors who got support from project. Some of them were already used to grow legumes on their lowlands but not on their slopes. This multiplying effect was facilitated by the creation of seed banks allowing a wider number of people to test groundnut without additional investment from project. OFR also provided crucial additional information on agro-economic results of the main cropping systems implemented on

slopes in project area and their insertion in local farming systems. Trials also led project staff to learn more about recommendation to be done at local level for yields improvement (sowing time, density).

Moreover, most trials and demonstration plots were supported though the establishment of farmers' groups. When most of farmers' plantations are grouped in the same location, it arouses an emulation, especially in one commune where most of farmers replanted luong on the same hill (after several years of sugarcane) and enthusiastically named it "the green hill" (*doi si xanh*). This enthusiasm was reinforced by the numerous visits of their plots organized for farmers and local authorities from other communes, districts and provinces (and even three visits of Laotian people). These visits also allowed to initiate the spreading of these practices in these new locations (for example, after their visit of the "*green hill"* in Kien tho, farmers from Phu Tho, supported by Hadeva, showed a great interest for intercrop and agreed to grow them in their new luong plantations). Farmers running trials or demonstration plots were involved in each visit, and their exchanges with farmers from other places were fruitful in outlining the interest of legumes to be intercropped with luong on steep slopes.

Last, regular information and consultation of local authorities and extension services (who were more particularly involved in the pre-selection of techniques to be tested, the design of technical leaflets, restitution seminars) was also a factor of success. They appreciated the new developed practices and their positive impact on both farmers' incomes and environmental sustainability. They were supportive and facilitate project activities (by delivering on time authorizations to work in the area, to organize trainings, to establish farmers groups …)

Adoption of "Best Practices" hindered by Farmers' Short-Term Agendas

Groundnut proved to be the most suitable crop to be intercropped with newly planted luong on slopes, as it ensures high and stable income while limiting soil erosion and promoting bamboo growth. Nevertheless, other crops, such as cassava and sugarcane or maize, still arouse farmers' interest, limiting groundnut spreading on slopes. These crops also compete with the expansion of luong plantations. In Northern Provinces of Vietnam, these three crops are widely and unsustainably cultivated on slopes, despite their negative impact on soil erosion, for several reasons. Predominance of these crops in the landscape is in a large extent linked to the proximity of processing companies. Indeed, these companies offer several assets to the farmers. They provide them with technology packages (trainings, ploughing engines, access to quality seeds or seedlings, quality-fertilizers, technical advises or technical sequence...), advances to buy inputs (seeds, fertilizers, labour...) and guarantee the production purchase (but usually not the price). This way, factories compensate for three main constraints of farmers: the lack of technical advises, the access to quality inputs and the access to capital. Moreover Vietnamese farmers mostly focus on short-term agendas and are easily attracted by short-term speculative crops such as cassava and maize mainly produced to be sold abroad. As illustrated by recent evolution of cassava prices (see above part on agro-economic results), such short-term orientated speculations are often risky.

In this context, the promotion of other models and strategies requests a specific and comprehensive support, involving all concerned stakeholders (farmers, local authorities, technicians, local agricultural extension services, agronomists, companies likely to provide input or credit…) to identify and spread best practices and provides farmers with the means to adopt them. Such approach requests appropriate means and time.

The scale of intervention into question

Gret experiences on intercropping in particular and luong in general show that the selection and sustainable diffusion of best practices request a relatively large scaled intervention, in terms of time and locations. First of all, running trials and implementing extension work in several locations (several districts and communes) allow to adjust to the variability of soil conditions (slopes, soil fertility due to different cropping history…) and economic situations (kind of infrastructures, impact of processing factories…). This variability induces the predominance of different cropping systems (sugarcane in Kien Tho, Cassava in Xuan Phu) with various yields (Table 5). As a consequence, results obtained in one commune may not appear interesting in another one (for example, trials ran in Kien Tho will not convince Tan Thanh farmers, as income obtained Kien Tho for groundnut are lower than the one obtained for cassava in Tan Thanh where soil fertility is higher).

Table 5: Comparison of yields obtained by OFR in 2008 in 3 communes

Commune (district)	*Main characteristics*	*Groundnut*		*Fresh Cassava*		*Sugarcane*	
		Yield kg/ha[1)]	*NI million VND/ha*	*Yield T/ha*	*NI million VND/ha*	*Yield T/ha*	*NI million VND/ha*
Tan Thanh (Thuong Xuan)	Groundnut and cassava were grown on cleared plots (following degraded forest)	4600	33,0	22,0	21,9	37,0	3,6
Kien Tho (Ngoc Lac)	All crops were grown on plots eroded by several years of monoculture (sugarcane, cassava…)	2280	13,7	11,0	14,3	40,0	14,0
Xuan Phu (Quan Hoa)	Groundnut and cassava were grown on cleared plots (after degraded forest)	3530	32,8	20,0	20,6	-	-

[1)] Results obtained for two seasons (spring + autumn)

Furthermore, it appears essential to implement OFR during a long period (never less than 2 years) to overcome the intra- and inter- variability of climatic conditions and measure impact of crops such as legumes on soil fertility. Crops grown in spring 2008 were affected by the bad weather conditions which occurred (the longest and coldest winter faced by North Vietnam in more than 20 years). Running trials at this time only would not have show the real potential of groundnut as an intercrop with bamboo. Trials on planting and managing luong request even longer trial period as 2 to 5 years are necessary before observing first results (in mature plantations, impact of tending practices on new shoots are obvious after 2 years of applications, while for new plantation, ones has to wait first harvest before assessing impact of introduced techniques on productivity).

Moreover, techniques introduced are often new and considerably change farmers' uses on luong plantations. Beyond the introduction of new practices, it is a matter of changing the way farmers consider their plantations. Indeed, farmers currently consider them as "safety bank", in which they invest a minimum amount of time and money (which they prefer to invest for short-term speculative crops (see § 4.b.)). To initiate a change in farmers' conception, it is essential to give them the way to test new practices during several seasons. The first years, farmers were reluctant to implement techniques proposed by agronomists (higher density, more fertilizer, more care ie. more labour), but season after season, seeing high potential of groundnut they agreed to apply these practices (even on demonstration plots, without financial support).

Beyond the issue of project scale, is the one of long run impact of such participatory research once the project withdraws the locality. Final target of such project should not be the development and diffusion of one set of new technologies, but the transfer of research and experimentation capacities to local actors to ensure farmers will be able to keep adjusting them with changing circumstances in a sustainable way. Project already paved the way to tackle this issue by supporting the creation of a local NGO (recently registered as a local cooperative) already skilled in the implementation of OFR and participatory activities. This cooperative already wins some legitimacy among local authorities and farmers, thanks to the concrete technical results already obtained, discussed and transferred by the project and the cooperative. A complementary approach could be to reinforce farmers' capacities to innovate, experiment and adapt their practices by themselves, without external support, and move toward a "farmer to farmer" experimentation network. In this case, further work has to be done to reinforce farmers' capacity to identify problems they want to address, design trials, implement experiments, assess and share results, without external support, or with a limited one from local NGO (for example to get access to information or technologies not available locally).

Conclusion

Development of Luong bamboo production and supply chain is commonly described as a way to reduce poverty while preserving environment in North Vietnam poorest districts. Despite an active period of research on luong plantation and management practices of luong in the 70's, Vietnamese authorities are currently granting few means to research and extension work for this crop.

One may be attracted to solve this issue by using results of past researches or running some additional researches in one site. However, Gret field experiences on luong supply chain in general and intercropping in new luong plantation in particular, outlines the high relevance of a more participative and comprehensive approach. Indeed development of luong and introduction of new practices are hindered by several constraints (especially the competition with other crops providing a priori a better answer to farmers' short term agendas). Such constraints have to be removed progressively and in an iterative way, by defining practices well adapted to local conditions and constraints. On-Farm-Research, with a participatory definition of tested practices and trials planning and a joint evolution was proved to be an efficient way to demonstrate local interest of these practices and sound their sustainable adoption.

However adoption of such practices is hindered by short-term agendas of farmers and competition from other crops whose adoption is facilitated by services offered by agro-factories. As a consequence promotion of more sustainable model ensuring higher income request a relatively large scaled intervention, in terms of time and locations which may exceed project framework always limited in time. To ensure a sustainable agricultural development, project has to reinforce research and experimentation capacities of local actors. It could be done by the creation or reinforcement of local NGOs or services cooperative able to support farmers and extension services in adapting practices to new constraints. Capacities of farmers currently involved in trials could also be enhanced to create farmers to farmers' experimentation networks able to define, implement and assess their own experimentation and spread technologies and practices allowing to develop themselves their agriculture in a sustainable way.

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References

- Affholder, F.; Jourdain, D.; Morize, M.; Dang Dinh Quang; Ricome, A. 2008. Eco-intensification dans les montagnes du Vietnam : Contraintes à l'adoption de la culture sur couvertures végétales (Ecological intensification in the mountains of Vietnam: Constraints to the adoption of cropping systems based on mulches and cover crops). Cahiers Agricultures vol. 17, n° 3, mai-juin 2008. pp. 289-296.
- Chambers, R.; Ghildyal, B.P. 1985. Agricultural Research for Resource-Poor Farmers: The Farmer-First-and-Last-Model. Discussion Paper No. 203, Institute of Development Studies. University of Sussex: Brighton, England, *Also in* Agricultural Administration. pp. 1-30.
- Farrelly, D. 1984. The book of bamboo. Sierra Club Books, San Francisco
- GRET. 2008. Luong Development Project - 2008 Annual Report
- Howeler, R.H. 2002. Sustaining cassava farmers and our earth: background of the Nippon foundation project in Asia, 7th regional cassava workshop, CIAT, Bangkok, 2002. pp.315-332.
- Jouquet, P.; Podwojewski, P.; Bottinelli, N.; Mathieu, J.; Ricoy, M.; Orange D.; Toan Duc Tran; Valentin, C. 2008. Above-ground earthworm casts affect water runoff and soil erosion in Northern Vietnam. Science Direct, Catena 74 (2008). pp. 13-21.
- Kleinhenz, V.; Midmore D.J. 2001. Aspects of bamboo agronomy. Advances in Agronomy, Volume 74. pp. 100-145.
- MARD, 2000. Quy phạm kỹ thuật trồng và khai thác luồng (Guidelines for Bamboo (Luong) planting and harvesting techniques). Agricultural Publishing House. Hanoi. 16 pp.
- Nguyen Hoàng Nghĩa. 2005. Bamboos of Vietnam. Agricultural Publishing House. Hanoi.
- Nguyen The Dang. 2002. Farmer participatory research (FPR) on soil control erosion and fertilizer for cassava in Vietnam: 1999-2002, 7th regional cassava workshop, CIAT, Bangkok, 2002. pp.352-362.
- Nguyen The Dang. 2002. Farmer participatory research (FPR) on soil control erosion and fertilizer for cassava in Vietnam: 1999-2002, 7th regional cassava workshop, CIAT, Bangkok, 2002.
- Orange, D. ; PHAN Ha Hai; Lequeux, B.; HENRY, T. ; des Tureaux ; Pham Van Rinh ; Tran Duc Toan. 2007. Charges de fond et suspensions transportées par les eaux d'écoulement dans un petit bassin versant agricole sur pentes dans le Nord Vietnam. Actes des JSIRAUF, Hanoi, 6-9 novembre 2007. 6 pp.
- Orange, D. ;Tran Duc Toan ;Salgado, P. ; Nguyen Duy Phuong ; Nguyen Van Thiet ; Floriane, C.; Le Hoa Binh. 2008. Different interests, common concerns and shared benefits. LEISA Magazine, Magazine on Low External Input and Sustainable Agriculture, june 2008, Volume 24, N°2. pp.12-13
- Podwojewski, P.; Orange, D.; Janeau, J.L. ; Duc Toan Tran. 2008. Land-use impacts on surface runoff and soil detachment within agricultural sloping lands in Northern Vietnam. Science direct. Catena N°74. pp. 109-118
- Prosperity Initiative. 2008. Forest Science Institute of Vietnam 2008. Report on results of research on bamboos in Vietnam. 21p.

- Putthacharoen S., Howeler R.H., Jantawat S., Vichukit V., 1998, " Nutrient uptakes and soil erosion losses in Cassava and six other crops in a Psamment in eastern Thailand", Field Crops Research, CIAT, p.113-126.
- Rhoades, R. E. 1982. Understanding small farmers: sociocultural perspectives on experimental farm trials. CIP Social Science Department training document 1982-3, Lima, Peru: International Potato Center (CIP).
- Selener, D. n.d. « Typologies and Concepts : 1. Definitions, Assumptions and Types of Farmers' Participatory Research, IDRC, http://www.idrc.ca/en/ev-85043-201-1-DO_TOPIC.html
- Steiner, G. 1985, Cultures associées dans les petites exploitations agricoles en particulier en Afrique de l'Ouest (Intercropping in tropical smallholder agriculture with special reference to West Africa). GTZ, Rossdorf: TZ Verlagsgesellschaft. pp. 347.
- Storey, P.J. n.d. Bamboo: a valuable Multi-purpose and Soil conserving crop. Storey, P.J., London, U.K.
- Thai Phien: Nguyen Cong Vinh, 2002. "Soil organic matter management for sustainable cassava production in Vietnam", 7th regional cassava workshop, CIAT, Bangkok, 2002. pp.234-250.
- Tran Dinh Tao. 2001. The fruit of the loam: The benefit costs of soil conservation in Vietnam". Summary of EEPSEA Research Report 2001-RR13, On-site Costs and Benefits of Soil Conservation in Mountainous Regions of Northern Vietnam, EEPSEA, http://www.idrc.ca/en/ev-8251-201-1-DO_TOPIC.html.
- Valentin, C.; Agus, F.; Alamban, R.; Boosaner, A.; Bricquet, J.P. ; Chaplot, V.; de Rouw, T. de A.; Janeau, J.L.; Orange, D.; Phachomphonh, K.; Do Duy Phai; Podwojewski, P.; Ribolzi, O.; Silvera, N.; Subagyono, K. ; Thiébaux, J.P.;Tran Duc Toan; Vadari, T. 2008. Runoff and sediment losses from 27 upland catchments in Southeast Asia: Impact of rapid land use changes and conservation practices. Science Direct. Agriculture, Ecosystem and Environnement N°128, pp.225-238.
- Vogel, A. 2008. "Intercropping in Bamboo Luong new plantations: methodology and results of trials carried out by LDP on short-term intercrops in Luong new plantations in spring and autumn 2007, Thanh Hoa Province Vietnam". GRET. 30pp.
- Vogel, A. 2008. "Intercropping in Bamboo Luong new plantations: methodology and results of trials carried out by LDP on short-term intercrops in Luong new plantations in spring 2008, Thanh Hoa Province Vietnam". GRET. 44pp.
- Vogel, A. 2008. "Intercropping in Bamboo Luong new plantations: methodology and results of trials carried out by LDP on short-term intercrops in Luong new plantations in autumn 2008, Thanh Hoa Province Vietnam". GRET. 38pp.
- Zhou, B.; Fu, M.; Xie, J.; Yang, X.; Li, Z. 2005. Ecological functions of bamboo forest: Research and Application. Journal of Forestry Research, 16(2), 2005. pp. 143-147

[1] List provided by the Ethnic Minorities Working Group (EMWG).

[2] Technical content was based on results from previous trials completed by information from the agricultural development state services at district level concerning standards and recommendation in the area for the related crops.

[3] Standards provided for lowland and intensive fertilization and tending practices

[4] Average yield obtained by excluding all plots which did not get yield. By taking them into account when, average is 600kg/ha

[5] Results not included in this table: yield in autumn = 5.1T/ha, with a Net Income = 11millions VND/ha with a ROI = 4

[6] Cassava monocropping system without fertilization.

[7] In autumn 2008, there were 2 farmers in Tan Thanh (where there was only 1 trial), 2 farmers in Phung Giao (where there was only 1 trial) and 8 farmers in Kien Tho (where there were several trials and numerous demonstration plots).