Report on Field Experiments in Maze-based farming system conducted in 2012 and 2013

1. Introduction-Summery of experimental results for trials conducted in 2010 and 2011.

In 2010, thirteen small scale participatory experiments were conducted in farmers' fields in eight villages in Son La and Lai Chau provinces. Assessments in all experiments focused on production and economic impacts of mini-terraces, minimum tillage combined with use of mulch and intercropping with legumes (live mulch). At two locations in Na Ot and La Nga soil loss caused by erosion was also measured over four years from 2010 to 2013 and results of soil loss are presented in separate report on erosion (Appendix 14).

In 2010 production was increased in all seven experiments where mulch was used, with an average increase of 0.9 T/ha when mulch was used on mini-terraces and 0.7 T/ha when mulch was used on slopes. The legume crops (black bean, rice bean, soya bean and peanut) had a positive impact in all 6 experiments with the average increase of yield of 0.8 T/ha.

During participatory evaluation of the experiments, basic economic analyses were conducted to compare existing farmer practices with experimental erosion management practices. Results showed that economic impact was related to the existing level of inputs used and connectivity with the market. In Ta Ngao village where the level of engagement with markets was very low and normal farmer practice was shifting maize production with no inputs, the use of mini-terraces and mulch together with high doses of fertiliser resulted in 150% increase of production but did not lead to significantly higher profitability because of high input costs. In Na Ot farmers were connected with the market and used low doses of fertilisers resulting in moderate yields and profitability. In these circumstances the increase in production that can be attributed to the use of mulch and cultivation on mini-terraces was not proportional to the increase in labour inputs, so profit expressed per day of work was lower than in the farmer's fields even though yield and income were higher. In Ban Bo, farmers were well connected with markets and practised high input cultivation but without adequate knowledge. Here improved crop management and intercropping with legumes resulted in significantly improved production and increased profit of farmers involved in the project. Although results demonstrate that erosion prevention methods did increase maize yields, the small size of the economic benefits indicates that they are not likely to provide sufficient incentive for farmers to adopt them. (Detail report on experiments conducted in 2010 is presented in Appendix 13a).

In 2011 the research agenda was based on a thorough evaluation of the results from the 2010 maize experiments involving both researchers and farmers and following the recommendations of project's mid-term review the number of experimental sites was reduced from eight to six and number of experiments from 16 to eight.

Erosion measurements in 2011 showed that mini-terraces and minimum tillage reduced erosion by 50% and zero tillage by 65% in comparison to conventional burn and plough soil cultivation. Yields were relatively high in all treatments ranging between 4.8 and 6.2 T/ha in Na Ot and between 6.8 and 7.2 T/ha in La Nga. There were no statistically significant differences in yield between tested soil cultivation options however the minimum tillage gave the highest yields at both locations. Participatory evaluation sessions showed that farmers prefer minimum tillage, involving the opening of a small trench using a hoe or a cultivator pulled by a buffalo to apply seed and fertilisers, and the use of mulch. In Na Ot where enough organic material was left on the fields from the previous maize crop and weeds to form an effective mulch layer, this option required less labour than the conventional practice. However, in La Nga additional mulch had to be brought in from neighbouring fields making minimum tillage less attractive to farmer.

In Giang Ma hedgerows with Guatemala grass were used for erosion prevention and while no measurement of soil loss was undertaken, the build-up of soil behind the hedgerows was a clear indication of its effectiveness. The farmer who practised the hedgerow technique has 5 cows and he found the forage produced by Guatemala grass as useful as maize. He decided to extend the area planted with Guatemala grass in 2012, which is clear indication that the use of tropical grasses as hedgerows is a viable option for erosion management for farmers who have a significant number of livestock.

Two successful consecutive crops were grown at all three locations assigned to these experiments (Ban Bo, Chien Chang and Pieng Sang). In Ban Bo, two maize crops were grown, with the second crop of maize yielding as high as the first maize crop, which resulted in a significantly increase in farmers' income of 73% in comparison to only one crop. The yield of the second maize crop was statistically higher in plots where mulch (from residues of the first maize crop) was used and where soya bean was sown as an intercrop, in comparison to plots that were not mulched. There were no significant differences in maize yield between plots sown with soya bean and where dead mulch was used. However growing soya beans as an intercrop provided additional economic benefit for farmers.

In Chien Chang, only legumes, including soya bean, mung bean and black bean, were grown as the second crop and they all resulted in a satisfactory yield and income (19 million VND/ha for mung beans, 22.7 million VND/ha for black beans and 8.1 million VND/ha for soya bean). The yield of the black bean crops was significantly higher in plots were mulch was used, while for soya bean and mung bean there were no statistically significant differences between mulched and non-mulched plots.

In Pieng Sang, pumpkin was grown as the first crop and maize with and without legume intercrop as the second crop. Pumpkin yield was overall very high, with pumpkin grown on fields with mulch yielding over 30T/ha and without mulch 25 T/ha. Pumpkin grown with mulch had statistically significantly higher yield than pumpkin grown without mulch. The pumpkin price, however, appeared to be low that season, so the additional investment in mulch offset the gain in yield.

Maize grown as second crop in Pieng Sang without and with mulch obtained high yields of 5.7 T/ha and 6.1 T/ha, respectively. As a high price of over 5,000 VND/kg of maize prevailed at harvest time, investment in mulch paid off. Peanut and soya bean sown as intercrop gave reasonable yields adding to the farmer income (peanut 18.0 million VND/ha and soya bean 7.3 million VND/ha), however, intercropping did not significantly influence the yield of

maize. Both legumes when grown with mulch had a significantly higher yield than sown without mulch.

The results of the trials at the Tay Bac Station in Son La showed that synergistic advantages of legume crops intercropped with maize which reduce sowing density of maize cannot compensate for the loss of income due to reduction in maize yield. Hence re-spacing of maize with a distance between two maize rows within the strip of 0.4 m and distance between strips of 1 m is the preferred intercropping option because it does not reduce number of maize plants grown per hectare (Fig. 1.1). In 2012 and 2013 re-spacing of maize rows was implemented in all experiments which had intercropping as an experimental treatment.

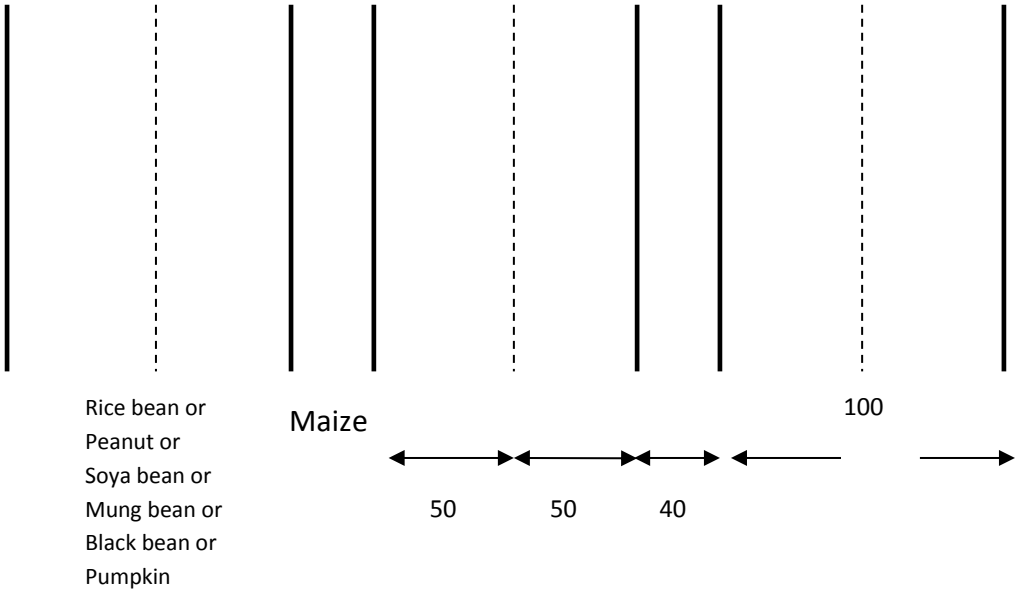


Fig1.1: Respacing of maize for intercropping

In this report results from four experiments were presented. In experiment conducted in Giang Ma commune, Tam Duong district of Lai Chau province a cropping system that includes maize, rice bean and Guatemala grass was evaluated over two rainy seasons from March 2012 to December 2013. In Ban Bo commune of Tam Duong district in the same time period cropping systems that include two crops within a rainy season were evaluated in flats, on gentle slope and steep slope. In period from February to October 2012 several cropping systems were evaluated in Pieng Sang village, Moc Chau district of Son La province. All systems included two crops within a rainy season. Maize and pumpkin were evaluated for the first crop and maize, soya bean and peanut as the second crop. Finally in Na Ot commune of Mai Son district and La Nga commune of Moc Chau district, both in Son La province, impact on yield and economic performance of several erosion management strategies were tested over two years.

2. . General Methods

All on-farm field experiments were conducted following participatory principles with farmers being involved in planning, setting up and post-experiment evaluation. However, experiments cannot be considered as fully participatory because farmers did not influence agronomical decisions like time of sowing or fertiliser use and they were not adequately involved in assessments during the course of the experiment. Nevertheless, participatory evaluation of trials conducted provided the opportunity for farmers to have a significant contribution in interpretation and analysis of the experimental results with the view of farmers shown in the "Conclusions and comments" sections of the report. The economic analyses presented in the report were performed with the farmers' participation and final approval.

Experimental design, main cultivation activities and fertiliser application were specific for each experiment and they are presented in the tabular form for each experiment in the Section 3 of this report. Description of erosion management cultivation technics evaluated, assessments of maize growth and production, and the statistical analysis of data were standardised across all experiments and are presented in this section.

2.1 Cultivation technics tested in soil erosion management trials

Treatment Plough

Organic material was removed from the cultivated area and area was ploughed using buffalo in experiments conducted on larger area or the whole area was cultivated using hoe.

Treatment Minimum tillage

Organic material in the field was preserved and only single trench was open at the sowing distance between rows. Trench was open using plough or hoe depending on the field size and farmers access to buffalo. Seed and fertilisers were placed into the trench and tranche was then closed. In some locations additional mulch was applied to build up organic material to 5-7 t/ha.

Treatment Minimum tillage plus rice bean intercrop

Same as Minimum tillage treatment with maize sown in strips containing two rows. Distance between maize rows within the strip was 0.4 m and distance between strips was 0.8 m. Rice bean was sown in one row in middle of the strip hence at distance of 1.2 m.

Treatment No till

Organic material in the field was preserved and only two whole were opened by hoe per sowing position: one for seed and one for fertiliser. In some locations additional mulch was applied to build up organic material to 5-7 t/ha.

2.2 Assessments of maize growth and production

The assessments of maize growth and production were conducted as follow:

1. Estimate of germination rate was done by randomly selecting in each replicate four rows that would be sown with maize. In each of selected rows length of 25 planting points were marked, e.g. if distance between seeds was 0.3m then 7.5 m was marked starting with seed position number 1 and finishing with seed position number 25. Seven to ten days later number of germinated plants per marked length of the row was counted and percentage germination was calculated.

2. The development stages V3-4, V7, VT, R1, R3, R5 (see Table 2.1 for details about Development stages) and time of sowing and harvest were recorded.

3. Measurements of plant height and the height to the first cob (ear) were made at R4 development stage. Ten plants were assessed per replicate (in most experiments that equals to 30 plants per treatment).

4. Characteristics of the cob including length of cob, cob diameter; number of seed rows; number of seeds/ row; weight of 1000 seeds at seed humidity of 14% were assessed using ten cobs per replicate.

5. Yield was estimated from a $2m^2$ area in each replicate. Calculation of yield (NSTT) was standardised at humidity of 14% using the following formula:

$$NSTT = \frac{EWP \times KE \times (100 - A^0) \times 10}{(100 - 14) \times S_{«}}$$

Where:

EWP=weight of cob when harvested (kg/2 m^2),
KE=weight of seeds/weight of cob
A^0 =moisture content of seed when harvested (%)
S = area harvested (2 m^2)

Table2.1: Development stages of maize.

Code	Vegetative Stage Name	Code	Reproductive Stage Name
VE	Emergence	R1	Silking
V1	First leaf	R2	Blister
V2	Second leaf	R3	Milk
V3	Third leaf	R4	Dough
Vn	N^{th} leaf	R5	Dent
VT	Tasseling	R6	Physiological maturity

2.3 Statistical analysis

Data for germination and yield were statistically analysed using a general linear model of analysis of variance (SPSS v 17) with treatments being the fixed factor and blocks (replicates) the random factor. Data were checked for compliance with assumption of normal distribution and variance homogeneity using PP plot and Levene's test for equality of error variances.

If the F test showed significant differences between treatments Ryan's Q test was used to separate differences between treatment means.

3. Experiments

3.1 Maize intercropped with rice bean and with Guatemala grass as hedgerows - Gieng Ma – Tam Duong-Lai Chao

3.1.1 Experimental design and cultivation protocol

Experiment was established in March 2012 and concluded in December 2013. The aim of the experiment was to assess maize, rice bean and Guatemala grass performance over relatively long period of time. Experiment was designed as participatory evaluation trial with Hmong ethnic minority farmers and did not have replication. During the experiment regular participatory monitoring was conducted and at the end of the experiment participatory evaluation with a group of eight Hmong farmers was conducted. Experimental treatments and main cultivation information are presented in Table 3.1.1

3.1.2 Results

Development indicators and yield of maize are shown in Table 3.1.2 for 2012 and in Table 3.1.3 for 2013. Production volume of Guatemala grass is shown in Table 3.1.4 for 2012 and Table 3.1.5 for 2013. In 2012 maize yield ranged from 3.8 to 4.2 t/ha and in 2013 it ranged from 4.5 to 4.7 t/ha. In areas where Guatemala grass was planted maize occupied 0.7ha and Guatemala grass 0.3ha. Productivity of this area in 2012 was 2.66t of maize and 1.4t of Guatemala grass and in 2013 it was 3.29t of maize and 2.74t of Guatemala grass.

Increase in yield of maize in 2013 can be contributed to better rainfall pattern. The Guatemala grass in 2013 was in its second year of development so it had a stronger root system and it was harvested continuously for 12 months while in 2012 Guatemala grass was transplanted in March from planting material produced in NOMAFSI research station and the first harvest was in May 2012, so it was harvested for only seven months.

In both years rice bean developed well with an estimated production of fresh biomass at about 10t/ha but after maize was harvested rice bean was outperformed by weeds and did not produce seeds in harvestable quantities.

3.1.3 Conclusions and Comments

Farmer's evaluation of cultivation system using Guatemala grass and maize was very positive but farmers did not consider growing rice beans as a viable option. The positive evaluation of Guatemala grass and maize production system was confirmed by farmers attending farmer field schools. Further research is necessary to evaluate the possibility of using rice bean as livestock feed and to develop agronomical practices that would maintain growth of rice bean after maize harvest for an additional two to three months until pods develop and can be harvested. There is a strong opinion among farmers in Son La province that there is a good market for rice bean which does not seem to be present among Lai Chao farmers so their motivation to maintain rice bean after maize harvest is very low. Market research to establish profitability of rice bean production in Lai Chao is necessary.

Table 3.1.1: Treatments and major cultivation information for experiments in Gieng Ma – Tam Duong – Lai Chau in 2012 and 2013

Experiment	Farmer names	Land area (m^2)	Treatment	Crop	Sowing density (m)	Fertiliser (kg)	Sowing/harvest
Erosion management (no soil loss measurements) Non-replicated experiment.	1. Do	1,500	T1 B& P T2 MT+ RB sown same time as MZ (2012 only) T3 MT+RB sowing after weeding (approximately 30 days after MZ) T4 Guatemala grass hedgerows + RB sowing after weeding	MZ Bioseed 9698 all treatments RB local variety Guatemala grass	MZ 0.7x0.3 T2:RB sown in same row as maize at distance of 0.5 m between plants T3: RB sown between rows of maize at 0.5 m between RB plants. Guatemala grass sown at 5 m.	**At sowing:** 500 NPK **1st dressing:** 100 Urea 50 Kaliclorua **2nd dressing:** 100 Urea 50 Kaliclorua	**2012:** **MZ** 28 March/23 July **RB** 28/03 not harvested **Guatemala grass** Transplanted 28/03 and continuously harvested in 2012 and 2013. **2013:** **MZ** 3 April/30 July
Demonstration Guatemala grass	1. Do	3,500	Guatemala grass hedgerows	MZ Bioseed 9698	0.7x0.4	**At sowing:** 500 NPK **1st dressing:** 100 Urea 50 Kaliclorua **2nd dressing:** 100 Urea 50 Kaliclorua	

Table 3.1.2: Development indicators and yield of maize variety Bioseed 9698 in 2012

Treatment	TGST (Day)	Germination rate (%)	Full height (cm)	Yield (t/ha)
Control	122	83	147	4.1
Rice bean intercropped with maize at the same time	122	78	154	4.2
Rice been sown after sowing maize	122	80	151	4.4
Maize + Guatemala grass	122	81	159	3.8

Table 3.1.3: Guatemala grass' yield presented for each harvest in 2012

	May	July	August	October	November	December
Volume (kg/3000m^2)	120	250	260	300	320	150
Calculated volume (kg/ha)	400	833	867	1000	1067	500

Table 3.1.4: Development indicators and yield of maize variety CP-999 in 2013

Treatment	TGST (Day)	Germination rate (%)	Full height (cm)	length of cob (cm)	P 1000 seeds (g)	actual yield (ton/ha)
Control	118	90	215	16.3	389	4.5
Rice been sown after sowing maize	118	92	218	16.9	389	4.6
Maize + Guatemala grass	118	90	219	17.2	389	4.7

Table 3.1.5: Guatemala grass' yield presented for each harvest in 2013

	Feb	Mar	April	May	Jun	July	Aug	Sep	Nov	Oct	Dec
Volume (kg/3000m^2)	90	200	300	360	410	400	360	210	180	150	80
Calculated volume (kg/ha)	300	667	1000	1200	1367	1333	1200	700	600	500	267

3.2 Two crops within a rainy season grown in flat field, on gentle slope and steep slope – Ban Bo – Tam Duong-Lai Chao

3.2.1 Experimental design and cultivation protocol

Experiment was established in March 2012 and concluded in December 2013. The aim of the experiment was to assess the viability of two crops within a rainy season on gentle and steep slopes. In 2010 and 2011 it was established that two crops can be grown in flat areas but there were still doubts whether this could be replicated on sloping lands. In 2012 and 2013 the experiment was established on a gentle slope (of approximately 10 degrees) and on a steep slope (approximately 30 degrees) but with established small terraces about two metres wide. During the experiment regular participatory monitoring was conducted and a participatory evaluation involving a group of five farmers was conducted at the end of the experiment. Experimental treatments and main cultivation information are present in Table 3.2.1. Experiment was designed as randomised complete block with four replicates.

3.2.2 Results

In 2012 for the first crop the yield of maize in flat areas has reached 5.5t/ha, on gentle slopes 4.3t/ha, and on steep slopes 3.9t/ha. For the second crop the yield of maize in flat areas was 6.3t/ha, on gentle slopes 5.5t/ha, and on steep slopes 4.7t. There were significant differences in maize yield for the first crop and for the second crop at p=0.05 between flat, gentle, and steep slopes. There were no differences in yield between mulched and non-mulched treatments (Figure 3.2.1 and 3.2.2). Maize yield for the first crop was significantly higher when maize was grown on flat land then on gentle slopes or steep slopes and yield was also significantly higher when grown on gentle slopes in comparison to steep slopes. For the second crop, maize yield was significantly higher when maize was grown on flat land than on steep slopes but there were no significant differences in yield between maize grown on flat land and gentle slopes and between maize grown on gentle slopes and steep slopes.

For soya bean, which was only sown in the second crop, the yield reached 1.05 t/ha in flat land, 1.34 t/ha on gentle slopes, and 0.96 t/ha on steep slopes. There were no significant differences between treatments in yield of soya bean.

In 2013 maize yield for the first crop has reached 5.5t/ha on flat land and gentle slopes, and 3.5t /ha on steep slopes. For the second crop maize yield was lower than in 2012 reaching only 4.1 t/ha on flat land, 4.0 t/ha on gentle slopes and 3.1 t/ha on steep slopes, however soya bean yield was at the same level as in 2012 reaching 1.0 t/ha on flat land, 1.3 t/ha on gentle slopes and 0.9 t/ha on steep slopes. Similar to 2012 there were significant differences in maize yield for the first crop and for the second crop at p=0.05 between flat, gentle, and steep slopes. There were no differences in yield between mulched and non-mulched treatments (Figure 3.2.3 and 3.2.4).

Maize yield for the first and the second crop was significantly higher when maize was grown on flat land then on gentle slopes or steep slopes but there were no significant differences between yields recorded when maize was grown on gentle slopes and on steep slopes.

For soya bean significantly higher yield was recorded when soya bean was grown on gentle slopes than when it was grown on flat land and steep slopes. There were no significant differences between yields recorded on flat land and steep slopes.

The production of the first and second maize crop and the production of soya bean grown as the second crop was profitable when income and inputs other than labour are considered regardless of the steepness of the slope in 2012 and 2013 (Table 3.2.2, 3.2.3 and 3.2.4). However, higher profitability was recorded when crops were grown in flat land than if they are grown on the slopes. Growing two crops per year increased return per land area.

When return is analysed based on the input of labour then returns per labour-day in 2012 for the first crop of maize grown on steep slopes of 115,000 to 120,000 VND per labour-day was below the ongoing rate for hired labour at the time of 150,000 VND. For the second crop growing maize gave returns above the rate paid for hired labour regardless of the slope inclination however soya beans gave returns below far below the rate paid for hired labour.

In 2013 when due to the late start of the rainy season yield was lower than in 2012 only the first crop of maize grown on flat land and gentle slopes gave returns marginally higher than the rate for paid labour. These results indicate that growing maize is just marginally profitable if labour have to be paid. If current trend of increased employment opportunities in NW Vietnam continue there is possibility that farmers will reduce maize production and enter labour market.

3.2.3 Conclusions and Comments

Over the four year of the project activities in Ban Bo farmers experienced benefits of growing two crops within a rainy season and by the end of the project two crops were grown on large scale at approximately 150 ha of flats and gentile slopes. Farmers' preference is to grow two crop of maize and only few farmers grow soya bean as the second crop. Farmers concluded that there is no much benefit of mulching in the first crop but they use stable of the first maize crop as mulching material for the second maize crop. Using maize stable as mulching material does not require much labour and benefits of mulching are more visible when used for the second crop because rainfall is significantly reduced in last few weeks of maize development.

Farmers also concluded that it is possible to grow two crops on gentile slope when minimum tillage and mulching are used. On slopes where terraces are needed amount of labour invested may not be worthwhile.

Table 3.2.1: Treatments and major cultivation information for experiments in Ban Bo – Tam Duong – Lai Chau in 2012 and 2013

Experiment	Farmer names	Land area (m^2)	Treatment	First crop	Sowing density (m) and sowing/harvest dates	Fertiliser (kg)	Second crop	Sowing density (m) and sowing/harvest dates	Fertiliser (kg)
2 crops/year over 2 years on sloping and flat land **Design:** Replicated complete block with 3 replications, replicated over 2 years	Slope: Min terraces: 1. Liem Terraces: 2. Khe Flat: 3. Nam	1. 2,000 2. 2,000 3. 2,000	First crop: T1 Maize T2 Maize + Mulch. T3 Maize T4 Maize + Mulch. Second crop: T1 Maize T2 Maize + Mulch. T3 Soya T4 Soya + Mulch.	MZ CP999 all treatments	0.7x0.3 **2012:** 1 April/21 July **2013:** 14-21 April/ 30 July	**At sowing:** 500 NPK **1st dressing:** 180 Urea 90 Kaliclorua **2nd dressing:** 180 Urea 90 Kaliclorua	**2012:** MZ NK4300 (T1&T2) SB DT 84 (T3&T4) **2013:** MZ CP333 (T1&T2) SB DT 08 (T3&T4)	MZ 0.7x0.3 SB 0.4x0.15 **2012:** **MZ** 4-12 Aug/ 24-28 Nov **SB** 4-8 Aug/ 28 Oct-2 Nov **2013:** **MZ** 9-11 Aug/ 26 Nov **SB** 9-11 Aug/ 1-3 Nov	**MZ** as per first crop **SB:** **At sowing:** 500 NPK **1st dressing:** 65 Urea 50 Kaliclorua **2st dressing:** 65 Urea 50 Kaliclorua
Demonstration trials 2 crop per year (MZ intercropped with SB in second crop) (2012 only)	1. Hien 2. Dung 3. Ly 4. Dien 5. Thinh	2,000 each Total: 10,000	Maize and soya bean intercrop	CP999, no plough, no mulch.	0.7x0.3	**At sowing:** 500 NPK **1st dressing:** 150 Urea 50 Kaliclorua **2nd dressing:** 150 Urea 50 Kaliclorua	CP999 Soya DT 12 Mulch	MZ 0.7x0.3 SB only 1 row between MZ rows 0.15 between plants in row (0.7x0.15)	**At sowing:** 500 NPK **1st dressing:** 150 Urea 50 Kaliclorua **2nd dressing:** 150 Urea 50 Kaliclorua

Figure 3.2.1: Maize yield (t/ha) first crop in Ban Bo 1/04 to 21/07 2012

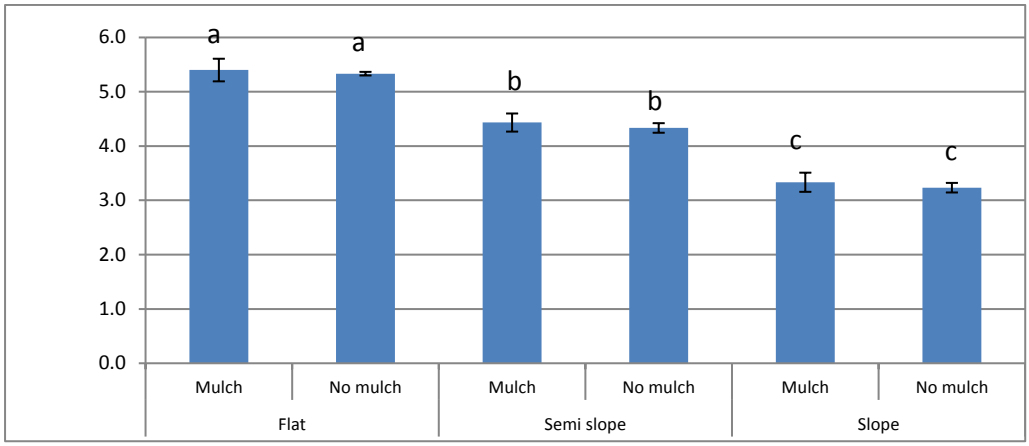


Figure 3.2.2: Maize and soya bean yield (t/ha) second crop in Ban Bo 4/08 to 28/11 2012

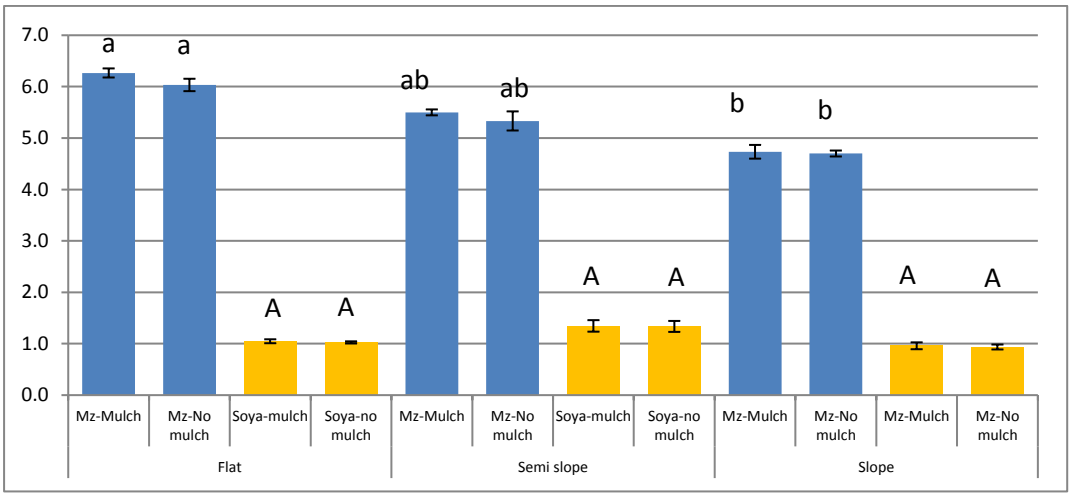


Table3.2.2 Economic analysis for first crop in Ban Bo 2012

Labour	Unit	Flat	Flat, mulch	Gentle slope	Gentle slope, mulch	Slope	Slope, Mulch
Prepare land	labours/ha	15	15	17	17	17	17
Sowing	labours/ha	20	20	22	22	22	22
Mulching	labours/ha	0	5	0	6	0	6
Fertilizer dressing	labours/ha	15	15	16	16	16	16
Weeding	labours/ha	25	18	26	19	26	19
Harvest	labours/ha	20	20	21	21	21	21
Total		**95**	**93**	**102**	**101**	**102**	**101**

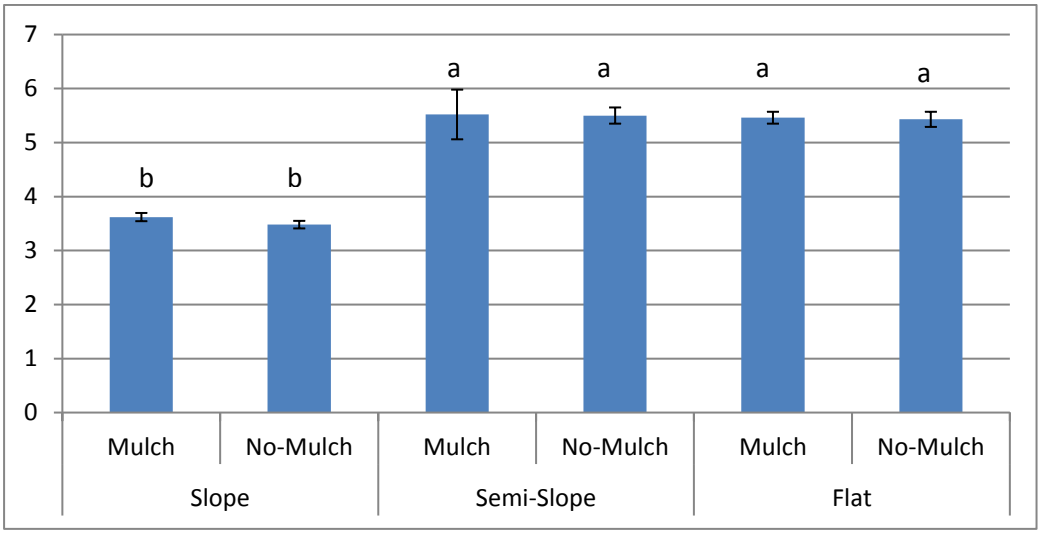
Input	Price (vnd)	Flat	Flat, mulch	Gentle slope	Gentle slope, mulch	Slope	Slope, Mulch
Seed (kg/ha)	80,000	20	20	20	20	20	20
NPK 5:10:3 (kg/ha)	5,500	500	500	500	500	500	500
Urea 46% (kg/ha)	10,400	360	360	360	360	360	360
Kali (kg/ha)	18,000	180	180	180	180	180	180
Pesticide	6,000	5	5	5	5	5	5
Total (1000 vnd/ha)		**11,364**	**11,364**	**11,364**	**11,364**	**11,364**	**11,364**

Economic analysis	Unit	Flat	Flat, mulch	Gentle slope	Gentle slope, mulch	Slope	Slope, Mulch
Yield	*kg/ha*	5300	5400	4300	4400	3200	3300
Price	*vnd/kg*	6000	6000	6000	6000	6000	6000
Income	*1000 vnd*	31,800	32,400	25,800	26,400	19,200	19,800
Input	*1000 vnd*	11,364	11,364	11,364	11,364	11,364	11,364
Profit	*1000 vnd*	**20,436**	**22,308**	**14,436**	**15,036**	**7,836**	**8,436**
Profit/ working day		**215**	**240**	**142**	**149**	**77**	**84**

Table 3.2.3 Economic analysis for the second crop in Ban Bo 2012

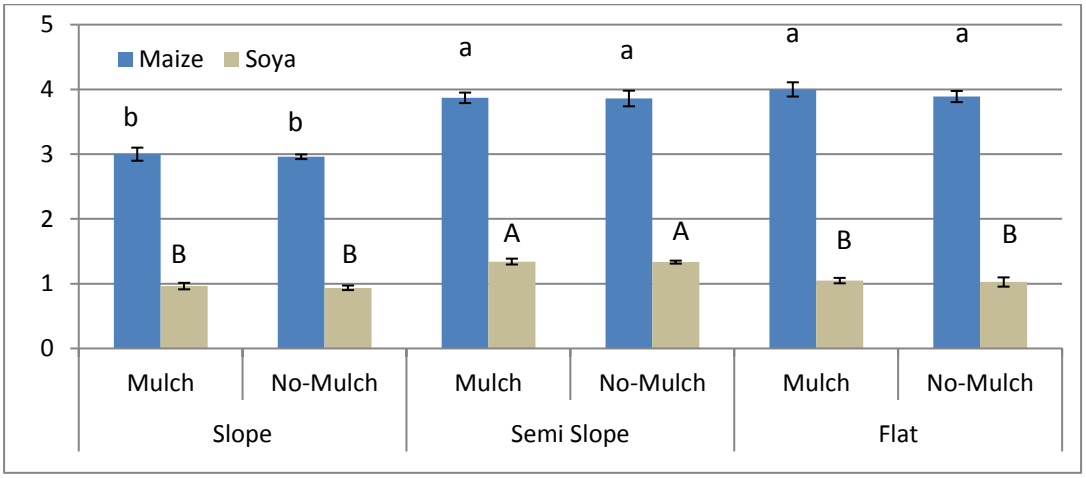
		Flat				Semi flat				Slope			
Labour	Unit	Mz-NM	Mz-M	Soy-NM	Soy-M	Mz-NM	Mz-M	Soy-NM	Soy-M	Mz-NM	Mz-M	Soy-NM	Soy-M
Prepare land	days/ha	15	15	15	13	17	17	16	15	17	17	16	15
Sowing	days/ha	20	20	22	22	22	22	25	25	22	22	27	27
Mulching	days/ha	0	5	0	8	0	6	0	10	0	6	0	10
Fertilizer dressing	days/ha	15	15	18	18	16	16	18	18	16	16	18	18
weeding	days/ha	25	18	20	15	26	19	20	15	26	19	20	15
Spray pesticide	days/ha	-	-	10	10	-	-	10	10	-	-	10	10
Harvest	days/ha	23	23	13	13	21	21	15	15	19	19	12	12
Total		**98**	**96**	**98**	**99**	**102**	**101**	**104**	**108**	**100**	**99**	**103**	**107**
		Flat				Semi flat				Slope			
Input	Price (vnd)	Mz-M	Mz-NM	Soy-M	Soy-NM	Mz-M	Mz-NM	Soy-M	Soy-NM	Mz-M	Mz-NM	Soy-M	Soy-NM
Seed maize (kg/ha)	80,000	20	20			20	20			20	20		
Seed soya bean	40,000			80	80			80	80			80	80
NPK 5:10:3 (kg/ha)	5,500	500	500	500	500	500	500	500	500	500	500	500	500
Urea 46% (kg/ha)	10,400	360	360	130	130	360	360	130	130	360	360	130	130
Kali (kg/ha)	18,000	180	180	100	100	180	180	100	100	180	180	100	100
Pesticide	5,000	6	6	20	20	6	6	20	20	6	6	20	20
Total (1000 vnd/ha)		**11,364**	**11,364**	**9,202**	**9,202**	**11,364**	**11,364**	**9,202**	**9,202**	**11,364**	**11,364**	**9,202**	**9,202**
		Flat				Semi flat				Slope			
Economic analysis	**Unit**	Mz-M	Mz-NM	Soy-M	Soy-NM	Mz-M	Mz-NM	Soy-M	Soy-NM	Mz-M	Mz-NM	Soy-M	Soy-NM
Yield	*kg/ha*	6267	6033	1048	1026	5500	5333	1347	1337	4733	4700	960	937
Price	*VND/kg*	6,000	6,000	18,000	18,000	6,000	6,000	18,000	18,000	6,000	6,000	18,000	18,000
Income	*1000 VND/ha*	37,602	36,198	18,864	18,468	33,000	31,998	24,246	24,066	28,398	28,200	17,280	16,866
Input	*1000 VND/ha*	11,364	11,364	9,202	9,202	11,364	11,364	9,202	9,202	11,364	11,364	9,202	9,202
Profit per land area	***1000 VND/ha***	**26,238**	**24,834**	**9,662**	**9,266**	**21,636**	**20,634**	**15,044**	**14,864**	**17,034**	**16,836**	**8,078**	**7,664**
Profit per labour input	***1000 VND/day***	**268**	**259**	**99**	**94**	**212**	**204**	**145**	**138**	**170**	**170**	**78**	**72**

Figure 3.2.3: Maize yield (t/ha) first crop in Ban Bo 14/04 to 30/07 2013



Error bars represent standard erroe of means

Figure 3.2.4: Maize and soya bean yield (t/ha) second crop in Ban Bo 9/08 to 26/11 2013



Error bars represent standard erroe of means

Table 3.2.4: Economic analysis for gthe first and the second crop in Ban Bo 2013(1000 VND)

Land	Treanment	First crop			Second crop			Profit/year
		Income	Input	Profit	Income	Input	Profit	
Flat	Mz-Mz, M	35340	11364	23976	26780	11364	15416	39,392
	Mz-Mz, NM	35503	11364	24139	26390	11364	15026	39,165
	Mz-Soy, M	35340	11364	23976	18360	9202	9158	33,134
	Mz-Soy, NM	35503	11364	24139	18280	9202	9078	33,217
Semi Slope	Mz-Mz, M	37642	11364	26278	26195	11364	14831	41,109
	Mz-Mz, NM	37011	11364	25647	26130	11364	14766	40,413
	Mz-Soy, M	37642	11364	26278	24240	9202	15038	41,316
	Mz-Soy, NM	37011	11364	25647	24160	9202	14958	40,605
Slope	Mz-Mz, M	23537	11364	12173	20345	11364	8981	21,154
	Mz-Mz, NM	22640	11364	11274	20020	11364	8656	19,930
	Mz-Soy, M	23537	11364	12173	16300	9202	7098	19,271
	Mz-Soy, NM	22640	11364	11274	16140	9202	6938	18,212

In 2013 price for maize was VND 6,500 and price for soya bean was VND 18,000. All other parameters inputs and days of labour were similar to the economic analysis in 2012 presented in Tables 3.2.2 and 3.2.3.

3.3 Two crops within a rainy season grown in flat field – Pieng Sang – Moc Chau-Son La

3.3.1. Experimental design and cultivation protocol

Experiment was established in February 2012 and concluded in October 2012. The aim of the experiment was to evaluate a possibility to intensify production in flat areas by growing maize or pumpkin as the first crop and maize intercropped with soya bean and/or peanut as the second crop. Experiment was designed as randomised complete block with 4 replicates.

3.3.2 Results

Development of maize variety AG 59 was much longer (131 days) when it was grown as the spring-summer crop than when it was grown as the summer-autumn crop (99 days). This was caused by early sowing time in February, so temperature and rainfall were lower in the first two months of the development in comparison to usual sowing time in April. Development of pumpkin was 117 until first harvest and 131 days to the last harvest.

Maize yield was higher for the spring-summer crop raging from 6.6 to 7 t/ha than for the summer-autumn crop which ranged from 4.6 to 6.7 t/ha. There were no significant differences ($p \leq 0.05$) in yield between maize grown with or without mulch for the first crop (Figure 3.3.1) but for the second crop yield was significantly higher when maize was grown with mulch (Figure 3.3.2).

Yield of pumpkin was significantly increased ($p \leq 0.05$) when mulch was used.

Both pumpkin and maize were highly profitable in spring-summer sowing providing several time higher returns per labour-day than ongoing rate of hired labour (Table 3.3.2). Return for pumpkin was more than double in comparison with maize sown as spring-summer crop. Intercropping with soya bean and peanut nearly doubled profitability of the second crop when compared with growing just maize (Table 3.3.3). However these results were achieved in flat field in area of Moc Chau with above average rainfall.

3.3.3 Conclusions and Comments

Farmers has seized opportunity of growing pumpkin as the first early crop follow by the maize as the second crop and they planted pumpkin on relatively large scale in year following the experiment (2013). Further market research is needed to establish size of the market for pumpkin in spring and early summer harvesting period to avoid overproduction if pumpkin is grown in a whole district.

Farmers evaluated use of mulch as beneficial for increase of yield but further research is needed to find way to source enough organic material to be used as mulch. Problem of increased rodent and insect pest population also has to be addressed before mulching will be used at large scale.

Table 3.3.1: Treatments and major cultivation information for experiments in Pieng Sang- Moc Chau 2012 in fields in flat areas

Experiment	Farmer names	Land area (m^2)	Treatment	First crop	Sowing density (m) and sowing/harvest date	Fertiliser (kg)	Second crop	Sowing density (m)	Fertiliser (kg)
2 crops per year **Design:** Replicated complete block with 6 replications	1. Song	4,000	First crop: T1 Maize T2 Maize + Mulch T3 Pumpkin T4 Pumpkin + Mulch Second crop: T1 Maize T2 Maize + Mulch T3 Maize intercropped with soya T4 Maize intercropped with soya + Mulch T5 Maize intercropped with peanut T6 Maize intercropped with peanut+ Mulch	Maize AG 59 (T1&T2) Pumpkin Long (T3&T4) Pumpkin Round (T5&T6)	MZ 0.7x0.3 24 Feb/05 July Pum. 2x2 Sowing: 24Feb 1st harv. 21 Jun 2nd har. 5 July	**MZ:** **At sowing:** 750 NPK **1st dressing:** 150 Urea 50 Kaliclorua **2nd dressing:** 150 Urea 50 Kaliclorua **Pumpkin:** **At sowing:** 500 NPK **1st dressing:** 50 Urea **2nd dressing:** 50 Urea	MZ AG 59 Mono-crop (T1&T2) MZ AG59 SB D8 (T3&T4) MZ AG59 Peanut Red local. (T5&T6) All crops: 6 July/ 8-13 Oct	MZ 0.7x0.3 for mono-cropping Re-spacing: Maize strip 0.4x0.3 Between strips 1 m Soya bean and peanut one row between maize 0.3x1.4m	**MZ:** **At sowing:** 750 NPK **1st dressing:** 150 Urea 50 Kaliclorua **2nd dressing:** 150 Urea 50 Kaliclorua **Soya bean and penut:** **At sowing:** 400 superP 30 Urea 50 Kaliclorua **1st dressing:** 30 Urea 50 Kaliclorua

Figure 3.3.1: Maize and pumpkin yield ('00kg/ha) first crop in Pieng Sang 24/02 to 21/07 2012

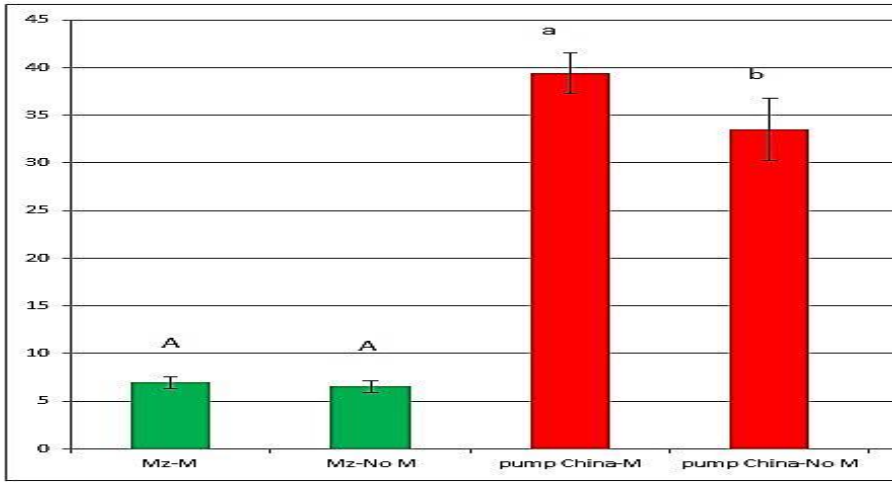


Figure 3.3.2: Maize yield (t/ha) second crop in Pieng Sang 06/07 to 8-13/10 2012

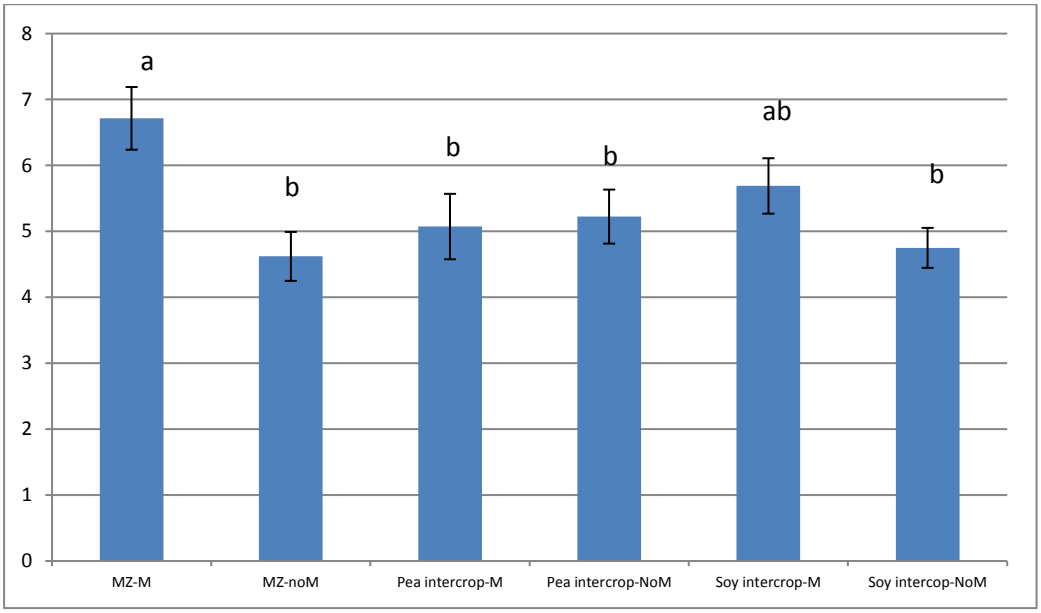


Table 3.3.2 Economic analysis for first crop in Phieng Luong

Labour	unit	Mz, NM	Mz, M	CN pump, NM	CN pump, M
sowing	days/ha	30	30	25	25
Mulch	days/ha		15		15
Spray herbicide	days/ha	4	4	4	4
Spray pesticide	days/ha			2	2
Fertilizers dressing	days/ha	15	15	12	12
Harvest	days/ha	20	20	23	23
Total		69	84	66	81

Input	Prices (vnd)	Mz, NM	Mz, M	CN pump, NM	CN pump, M
Seed (maize) (kg)	60000	15	15	0	0
Seed (CN pumpkin) (kg)	250000	0	0	27	28
Paraquat (lit)	70000	7	7	7	7
Mizin 80 WP (kg)	100000	2	2	0	0
Ofatox 400EC (bag)	25000	0	0	10	10
NPK (5:10:3)	4700	750	750	500	500
Urea	12000	300	300	100	100
Kali clorua	20000	100	100	0	0
Total (1000 vnd)		10715	10715	11040	11290

Economic analysis	Mz, NM	Mz, M	CN pump, NM	CN pump, M
Yield (kg)	6960	6550	33480	39420
Prices (VND/kg)	5700	5700	2200	2200
Income (1000 VND)	39672	37335	73656	86724
Input (1000 VND)	10715	10715	11040	11290
Profit (1000 VND)	28957	26620	62616	75434
Profit/ day (1000 VND)	420	317	949	931

Table 3.3.3 Economic analysis for second crop in Phieng Luong

Labour	unit	Mz, NM	Mz, M	Mz-Peanut,NM	Mz-Peanut,M	Mz-soya,NM	Mz-soya,M
sowing	labour	30	30	37	37	37	37
Mulch	labour		5		5		5
Spray herbicide	labour	3	3	2	2	2	2
Fertilizers dressing	labour	15	15	15	15	15	15
harvest	labour	21	21	25	25	27	27
Total		**69**	**74**	**79**	**84**	**81**	**86**

Input	Prices (vnd)	Mz, NM	Mz, M	Mz-Peanut,NM	Mz-Peanut,M	Mz-soya,NM	Mz-soya,M
Seed (maize) (kg)	60000	15	15	15	15	15	15
Seed (peanut) (kg)	80000	0	0	80	80	0	0
Seed (soya) (kg)	30000	0	0	0	0	24	24
Gramoxone 20SL (lit)	100000	4	4	4	4	4	4
Mizin 80 WP (kg)	100000	2	2	0	0	0	0
NPK (5:10:3)	4700	750	750	750	750	750	750
Urea	12000	300	300	300	300	300	300
Kali clorua	20000	100	100	100	100	100	100
Total (1000 VND)		**10625**	**10625**	**16825**	**16825**	**11145**	**11145**

Economic analysis	Prices (vnd)	Mz, NM	Mz, M	Mz-Peanut,NM	Mz-Peanut,M	Mz-soya,NM	Mz-soya,M
Yield maize (kg/ha)	5600	4620	6710	5220	5070	4750	5690
Yield peanut (kg/ha)	50000			413	646		
Yield soybean (kg/ha)	30000					638	745
Income (1000 VND)		25872	37576	49882	60692	45740	54214
Input (1000 VND)		10625	10625	16825	16825	11145	11145
Profit (1000 VND)		15247	26951	33057	43867	34595	43069
Profit/working day (1000 VND)		**221**	**364**	**418**	**522**	**427**	**501**

3.4 Comparison of erosion management cultivation options – Na Ot, Mai Son and La Nga, Moc Chau-Son La

3.4.1 Experimental design and cultivation protocol

The main objective of erosion management experiments was to measure soil loss and compare treatments' effectiveness in managing erosion. The results related to these objectives are presented in separate erosion management report (Appendix 14). In this report impact on yield of soil cultivation options that have been used for the erosion management including minimum tillage and mulching, minimum tillage and legume intercrop, mini terraces and mulching, and zero tillage are presented. Experiments were conducted between April and September in 2012 and 2013 in Na Ot, (Mai Son) and La Nga (Moc Chau).
Experiments were designed as randomised complete block with three replicates. Treatments and major cultivation information for Na Ot are presented in table 3.4.1 and for La Nga in table 3.4.2.

3.4.2 Results

Yield and economic analysis for Na Ot

In 2012 yield was generally high and varied from 4.1 t/ha for "no tillage" treatment and 5.9 t/ha for "plough" treatment (Fig 3.4.1). In 2013 yield was lower due to a prolonged dry period after sowing and ranged from 3.8 t/ha for "no tillage" treatment to 4.3 t/ha for "plough" treatment (Fig 3.4.2). In 2012 and 2013 there were no significant differences in yield between treatments ($F_{3, 6}$ = 2.47, p>0.05 and $F_{3, 6}$=0.531, p>0.05 respectively).

In 2012 net income ranged from 19,900,000 VND/ha for "no tillage" treatment to 30,440,000 VND/ha for "plough" treatment (Table 3.4.3). In 2013 net income was lowest for the "mini terraces" 17,356,000 VND and "no tillage" treatment 18,610,000 VND and highest for the "plough"" treatment 21,080,000 VND. Return per day of labour ranged between 280,000 and 350,000 VND in 2012 and between 247,000 and 265,000VND in 2013. The return per day of labour for all treatments in both years was higher than standard daily wage in 2012 and 2013 of 150,000 VND. It should be noted that mini-terraces were built in 2010 so the labour days shown in tables 3.4.3 and 3.4.4 do not include formation of the terraces. Farmers preferred minimum tillage and mulch treatment due to lower labour input and similar yield in comparison to their common, but for soil damaging practice, of removing organic material and ploughing entire field. There were increase of mice infestation in mulched treatments and appropriate mice control management strategy has to be developed to enable wider use of mulch.

Yield and economic analysis for La Nga

In 2012 yield La Nga site experienced unusually high incidence of mice damage that it seems affected some treatments more than another. Yield ranged from 2.3 t/ha for "plough" treatment and 5.0 t/ha for "no tillage" treatment (Fig 3.4.3). In 2013 as in other parts of NW Vietnam yield was lower than average due to a prolonged dry period after sowing and ranged from 3.6 t/ha for "no tillage" treatment to 4.6 t/ha for "minimum tillage combined with rice bean intercropping" (Fig 3.4.4). In 2012 and 2013 there were significant differences in yield between treatments ($F_{3, 6}$ = 4.60, p≤0.05 and $F_{3, 6}$=5.50, p≤0.05 respectively). In 2012 treatment "plough" had significantly lower yield

than “no till” treatment and in 2013 “no till” treatment had significantly lower yield than treatments “plough” and “intercropping”.

In 2012 net income ranged from 2,430,000 VND/ha for “plough” treatment to 18,630,000 VND/ha for “no tillage” treatment (Table 3.4.4). In 2013 net income was lowest for the “no tillage” treatment 10,048,000 VND and highest for the “intercropping” treatment 15,994,000 VND (Table 3.4.4). Income per day of labour except for treatment “plough” in 2012 and treatment “no tillage” in 2013 was higher for all treatments than minimum daily wage ranging from 207,000 to 246,000 VND, what is approximately 40 to 65% above standard wage.

3.4.3 Conclusions and Comments

Overall there are no significant differences in yield between evaluated cultivation options so decision which cultivation option to use can be made based on their benefit in management of erosion. However, previous trials in 2010 showed that establishment of mini-terraces is labour intensive and most farmers are unwilling to invest that extra labour. Availability of organic material for mulch is very limited when livestock grazing is not prevented during the dry winter period hence no many farmer can apply 5-7 t of mulch per hectare. Farmers are reluctant to use “no tillage” and their overall preference is to apply minimum tillage and use whatever organic material is in the field as mulch. Presented trials were conducted on relatively small plots and fact that for no tillage treatment manually operated hoe had to be used for sowing while for minimum tillage buffalo drawn plough can be used did not show in results. In practice minimum tillage is much easier to implement for majority of farmers who own buffalos hence the change of practice from ploughing entire field and removing organic material to minimum tillage with limited amount of mulch is more likely to happen than change to any other evaluated option. Further research is needed to improve performance of rice bean or alternative legumes and to improve management of rodent population.

Table 3.4.1: Treatments and major cultivation information for experiments in Na Ot- Mai Son in 2012 and 2013

Experiment	Farmer names	Land area (m^2)	Treatment	Crop	Sowing density (m) and sowing/harvest dates	Fertiliser (kg)	Second crop
Erosion management (soil loss measurements) **Design:** Randomised complete block with 3 replications	1. Lien 2. Pon	1. 500 2. 1000	T1 Plough T2 Minimum tillage + Mulch T3 Mini terraces + Minimum Tillage + Mulch T4 No tillage	**2012:** MZ NK54 for all treatments **2013:** MZ LVN66 for all treatments	0.7x0.3 **2012:** 15 Apr/8 Aug **2013:** 27/04/26 Aug	**At sowing:** 200 NPK **1st dressing:** 50 Urea **2nd dressing:** 50 Urea	None

Table 3.4.2: Treatments and major cultivation information for experiments in La Nga – Moc Chau 2012 and 2013

Experiment	Farmer names	Land are (m^2)	Treatment	First crop	Sowing density (m)	Fertiliser (kg)	Sowing/Harvest dates
Erosion management (soil loss measurements) **Design:** Randomised complete block with 3 replications	1. Khang	2,000	T1 Plough T2 Minimum tillage T3 Minimum tillage + rice bean T4 No tillage	**2012:** MZ NK54 for all treatments 2013 MZ C9901 for all treatments **2012&2013:** RB after herbicide application (14 days after MZ)	Maize 0.7x0.3 RB: Re-spacing: Maize strip 0.4x0.3 Between strips 1 RB one row 0.5 (0.7x0.5)	**At sowing:** 750 NPK **1st dressing**: 150 Urea 50 kaliclorua **2nd dressing:** 150 Urea 50 kaliclorua	**2012:** 2 May/11 Sep **2013:** 10 May/13 Sep

Figure 3.4.1: Maize yield (t/ha) in Na Ot in 2012

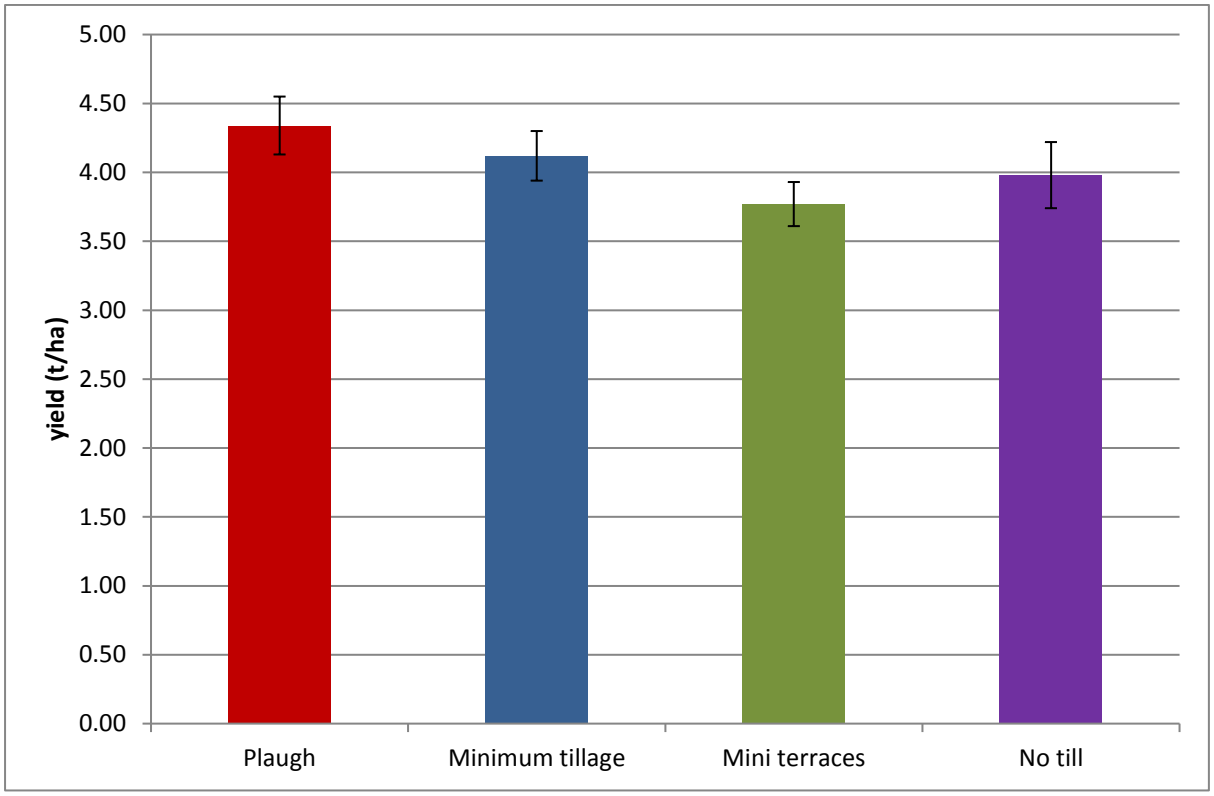


Figure 3.4.2: Maize yield (t/ha) in Na Ot in 2013

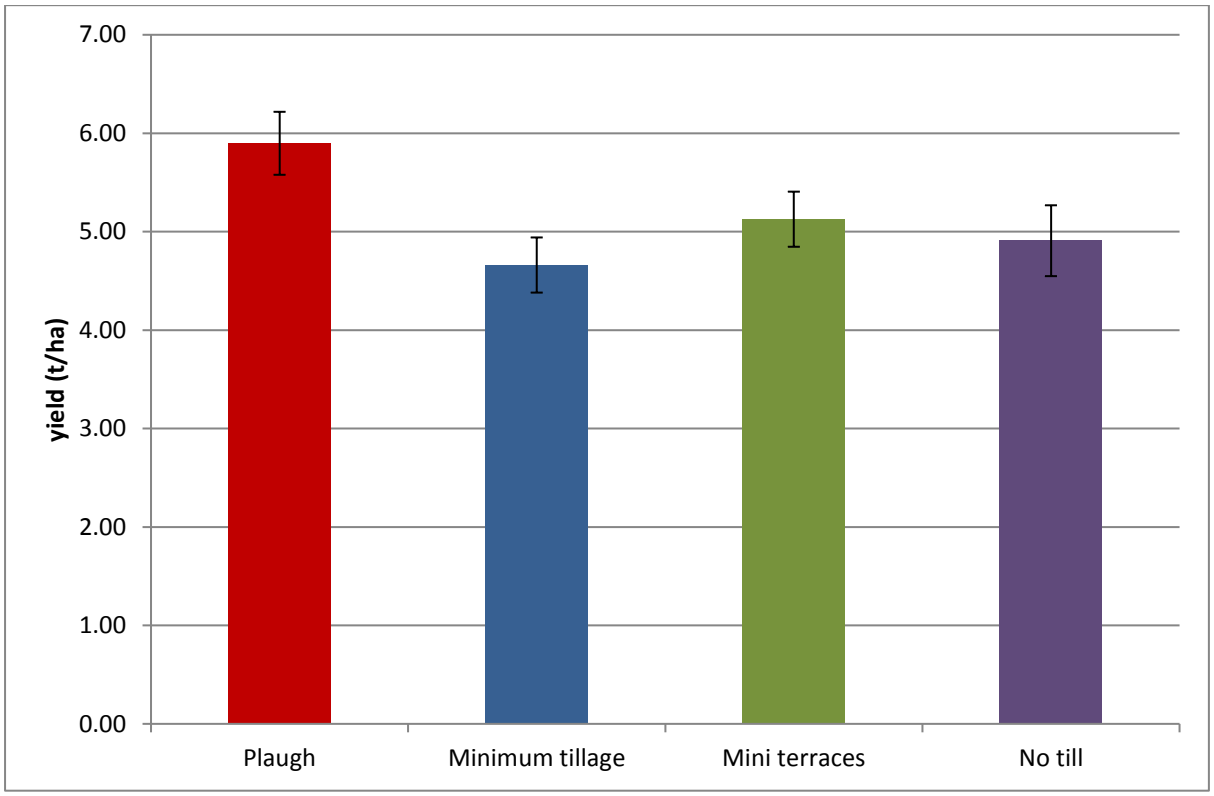


Figure 3.4.3: Maize yield (t/ha) in La Nga in 2012

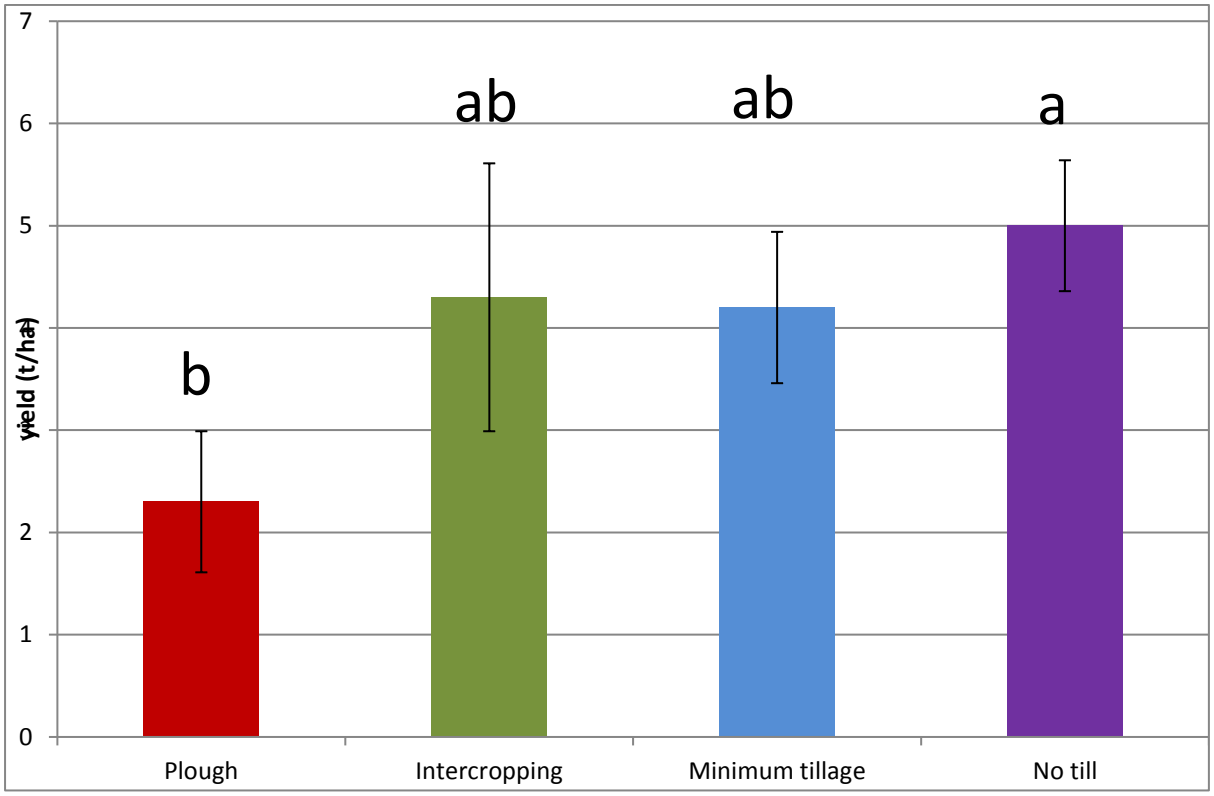


Figure 3.4.4: Maize yield (t/ha) in La Nga in 2013

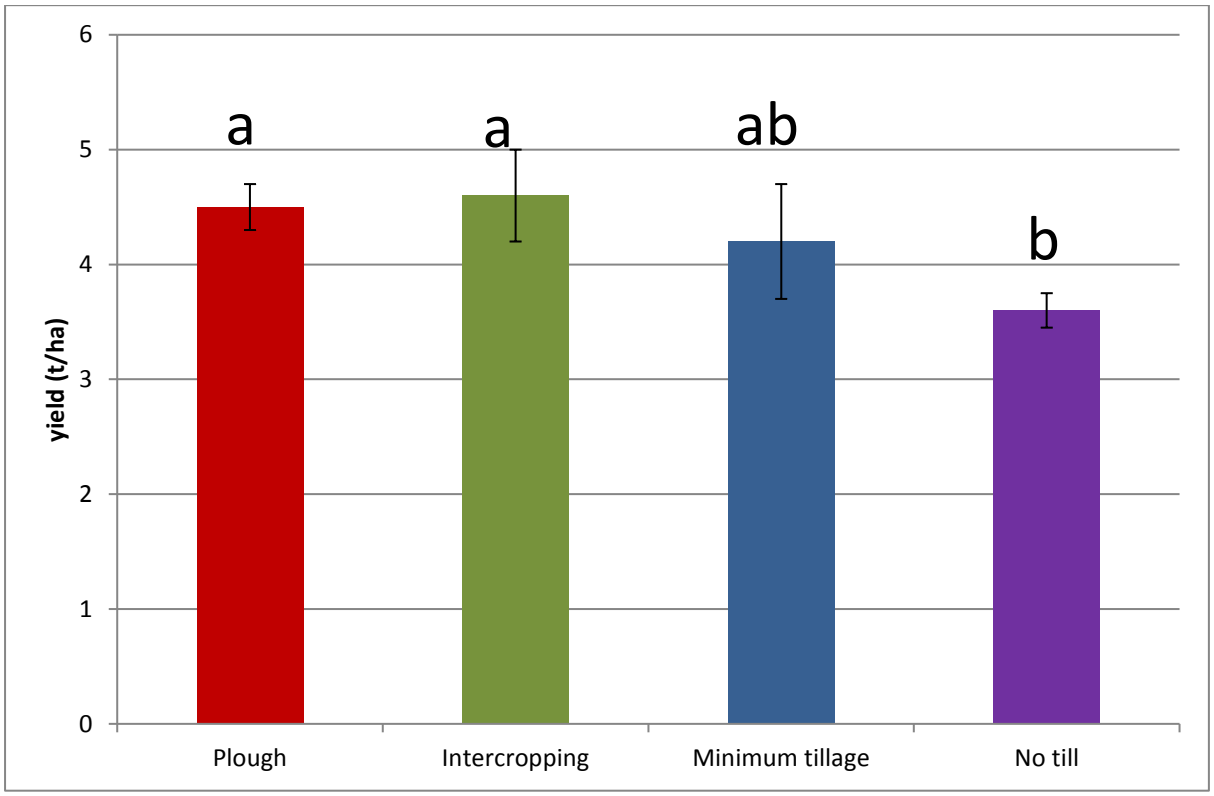


Table 3.4.3. Economic analysis of various erosion management options in Na Ot in 2012 and 2013

	Plough	Minimum tillage	Mini terraces	No till
2012				
yield (kg/ha)	5,900	5,130	4,660	4,190
Prices (vnd)	6,000	6,000	6,000	6,000
Income (1000 vnd)	35,400	30,780	27,960	25,140
Input (1000 vnd)	4,960	5,240	5,240	5,240
Profit (1000 vnd)	30,440	25,540	22,720	19,900
labour (days)	87	74	71	71
Profit/working day (1000 vnd)	350	345	320	280
2013				
yield (kg/ha)	4340	4121	3766	3975
Prices (VND)	6,000	6,000	6,000	6,000
Income (1000 VND)	26,040	24,726	22,596	23,850
Input (1000 VND)	4,960	5,240	5,240	5,240
Profit (1000 VND)	21,080	19,486	17,356	18,610
labour (day)	84	77	70	70
Profit/labour day (1000 VND)	250	253	247	265

Table 3.4.4. Economic analysis of various erosion management options in La Nga in 2012 and 2013

	Plough	Minimum tillage & Rice bean intercropping	Minimum tillage	No tillage
2012				
Yield (kg/ha)	2300	4300	4200	5000
Price (VND/Kg)	6000	6000	6000	6000
Input (1000 vnd)	11,370	11,475	11,375	11,370
Income (1000 vnd)	13,800	25,800	25,200	30,000
Profit (1000 vnd)	2,430	14,325	13,825	18,630
Labour (day)	63	65	65	90
Profit/working day (1000 vnd)	39	220	213	207
2013				
Yeild (kg/ha)	4510	4577	4200	3570
Price (VND/Kg)	6000	6000	6000	6000
Input (1000 vnd)	11,370	11,475	11,375	11,370
Income (1000 vnd)	27,067	27,469	25,194	21,418
Profit (1000 vnd)	15,697	15,994	13,819	10,048
Labour (day)	63	65	65	90
Profit/working day (vnd)	249	246	213	112