Results of field experiments in

MAIZE PRODUCTION SYSTEM

Conducted in 2010

in Son La and Lai Chai Province, Vietnam

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1. Executive summary

In 2010, the first round of field trials for the North West Vietnam project was conducted by NOMAFSI in collaboration with Tay Bac University and local extension service staff. Teams of field researchers and farmers implemented a total of 19 experiments in the maize based cropping system: 6 in Lai Chau province, 9 in Son La province and 4 at NOMAFSI Tay Bac Research Station. An overview of the locations of the field trials and farmers, researchers and extension staff involved is shown in Table 2.1.

The overall objectives of the trials were to: a) evaluate effectiveness of mini terraces and mulch for erosion prevention and the influence they have on maize growth and yield and; b) evaluate suitability of a range of legume crops for intercropping with maize and assess their impact on maize growth and yield. In addition to these objectives, new hybrid and non-hybrid varieties of maize were evaluated in a subset of these experiments, and the influence of maize planting density on yield was assessed in one experiment conducted at Tay Bac research station.

All experiments, except for the mulching experiment in Ta Ngao and the erosion trial in Gieng Ma, applied a randomised complete block design with 3 replicates (= blocks). Data for percentage of germination and yield were statistically analysed using mixed model of analysis of variance (SPSS v. 17).

All on-farm field experiments were conducted in a participatory manner with farmers involved in planning, establishment, maintenance and evaluation of the experiments. However, the implementation of the experiments cannot be considered fully participatory because farmers did not influence agronomical decisions like time of sowing or fertiliser use, and they were not adequately involved in data collection and assessment during the course of the experiment. Nevertheless, participatory evaluation sessions conducted after the harvest of the 2010 trials provided the opportunity for farmers to have a significant contribution in interpretation and analysis of the experimental results with the views of farmers shown in the “Conclusions and comments” sections of this report. Farmers’ contributions were pivotal in all economic analyses presented in the report.

Main findings of these experiments are:

1. The use of mulch increased maize yields, whether mulch was used on mini-terraces or without them. In 7 experiments, mulch alone and in combination with mini-terraces was compared with farmer practice of burning all organic material on the fields before sowing. The yield of maize increased in both mulch treatments. In 4 out of 7 experiments this increase was statistically significant. Average increase of yield over these 7 experiments was 0.7 T/ha when mulch was used without mini-terraces and 0.9 T when mulch was used on mini-terraces.
   In 3 experiments, mini-terraces without addition of mulch were directly compared to mini-terraces with mulch. Adding mulch increased yields in all 3 experiments but the increase was only statistically significant in one experiment. Average increase of yield that could be attributed to the use of mulch on mini-terraces was 0.3 T.
2. The impact of intercropping maize with legumes was evaluated in 6 experiments. In all these experiments maize was sown in strips of two rows with a narrow spacing of 0.4 m between rows within each strip. Spacing between the 2 strips of maize was 1 m. Legumes were sown in this 1m-

space between two maize strips. This intercropping arrangement did not reduce the number of maize plants sown in comparison with the number of maize plants planted in farmers' fields.
Black bean was trialled in 2 experiments, and rice bean, soya bean and peanuts in 3 experiments. Only the peanut crop was harvested at the end of the experiments, but the yield was low (< 1T/ha). All other legume crops were destroyed by pests and diseases before harvest. The legume crops, however, did have a positive impact on maize growth and yield. The yield of maize increased in all 6 experiments with statistically significance recorded in 5 out of 6 experiments. Average increase of yield over the 6 experiments was 0.8 T/ha.

3. It became apparent that the use of high doses of fertilisers alone within current farming practices is not economically viable. If higher use of fertiliser was adopted as part of a more comprehensive change in cultivation practices, including the use of hybrid varieties and high density planting, then yield increases of 4 to 5 times the current levels may be possible, justifying higher investments and resulting in increased income for farmers. This was demonstrated in the trials on Tay Bac Station, however suitability of the whole package needs to be confirmed under farmer conditions. Under the current socio-economic circumstances in most project locations, a high level of production intensification does not seem feasible yet because farmers do not have the financial means to increase external inputs, they lack technical knowledge to implement intensive cultivation practices, and there is scarcity of labour to apply high doses of fertilisers in the project locations. In future experiments lower fertiliser doses adapted to farmers' socio-economic conditions should be used.
4. In Giang Ma, the maize varieties Ha Giang Yellow and Ha Giang White were assessed on a farmer's field and they outperformed the local variety (unknown origin). Farmers expressed the intention to sow the Ha Giang varieties in their fields in 2011.
5. Seven hybrid maize varieties (LVN 14, LVN 81, LVN 154, LCH 9, LVN 146, LVN 99 and LVN 61) with short to medium growth duration were evaluated and compared to LVN10, a variety widely used by farmers in Son La province. Two experiments were conducted: one in a farmer's field in Chieng Chan Commune, Mai Son District, and the other at Tay Bac Research Station.
   Results from these experiments were not entirely consistent. In both experiments varieties LCH9 and LVN99 performed significantly better than the benchmark variety LVN10. Variety LVN146 was the best performing variety in the Tay Bac station experiment but it did not perform better than LVN10 in the Chieng Chan experiment. The other tested varieties did not have a significant advantage over the benchmark treatment.
   The inconsistencies between the results from the various experiments are mainly caused by the differences in growth duration (from sowing to harvesting) of the different varieties. Varieties LCH9, LVN99 and LVN146 had a growth duration of 94, 92 and 91 days, respectively, in the Chien Chang experiment, which was significantly shorter than the 106 days of the benchmark variety LVN10. However, in the experiment at Tay Bac station the growth duration was longer at 111, 110 and 112 days for LCH9, LVN99 and LVN146, respectively.
   These results indicate that varieties LCH9, LVN99 and LVN146 may be suitable for a cropping system of 2 consecutive seasons per year but further evaluation is necessary before final conclusions can be drawn.

6. There was a significant linear relationship between planting density and yield. Results indicate that a significant increase in yield can be achieved with increased planting density when couple with high fertiliser application. Modes of incorporating higher planting density in farmer practice have to be further investigated.

During participatory evaluation sessions for the experiments in Ta Ngao, Ban Bo and Na Ot in August and September 2010, basic economic analyses of the various treatments were done. The teams of field and farmer researchers compared existing farmer practices with experimental erosion management practices. Farmer researchers contributed to the estimation of work-days necessary for each production activity, cost of inputs and income from maize sales.

Main conclusions of these economic analyses are:

1. In Ta Ngao, level of farmer engagement with markets is very low. The use of mini-terraces and mulch together with high doses of fertiliser resulted in an increase of production of 150% but did not lead to higher profitability due to very high input cost. Analysis also showed that shifting cultivation practices in maize production (i.e. opening new production areas by cutting the forest for short term use of land followed by a long fallow period) with no use of external inputs, as is practised in Ta Ngao, currently remains an economically viable option for famers. However, population increase in the area and government restrictions on deforestation reduce the availability of land for shifting cultivation. As a result, the duration of the fallow period is becoming shorter, which eventually will make this type of farming unsustainable.
2. In Ban Bo, farmers are well connected to markets and use significant amounts of fertiliser but without substantial increases in yield, resulting in only moderate profitability of their crops. In these circumstances improved crop management practices, including more frequent use of smaller quantities of nitrogen fertilisers, mulching, and pest and disease management, significantly improved production in experimental fields and increased profits of farmers involved in the project.
3. In Na Ot, farmers are generally well connected to the market and use low amounts of fertilisers in their fields, resulting in moderate yields and profitability of their crops. Under such circumstances, application of very high amounts of fertiliser on experimental fields did not result in proportional increases of income and led to lower profitability of production in the experimental treatments compared to farmer practice. It can be concluded that increased investment in only one production component, in this case fertilisers, does not result in increased profitability if other factors in the cultivation system remain unchanged. It can also be concluded that the increase in maize production attributed to the use of mulch and cultivation on mini-terraces was not proportional to the increase in labour input, so profit expressed per day of work in the experiment was lower than in the farmers' fields.

   Based on the results from the 2010 maize experiments, the project team developed the research agenda for 2011. Major changes include (1) emphasis put on obtaining viable yields from the crop species used for intercropping, (2) introducing minimum tillage or no-tillage as an economically viable method that may assist in the prevention of erosion, and (3) the use of external inputs in experiments based on farmers' current use with only minor adjustments where necessary. More

effort will be put in precise measurements of erosion by focusing resources on only 2 sites rather than 4 sites in 2010. The research team will also focus much more on processes to encourage farmer participation in planning, execution and evaluation of the field experiments. To assist with the latter, comprehensive guidelines for participatory monitoring and evaluation have been developed and training for researchers and extension officers was conducted in September and November of 2010. The guidelines are a work in progress and are constantly updated to suit the conditions in the field.

2. Introduction

In 2010, the first round of field trials for the North West Vietnam project was conducted by NOMAFSI in collaboration with Tay Bac University and local extension service staff. Teams of field researchers and farmers implemented a total of 19 experiments in the maize based cropping system: 6 in Lai Chau province, 9 in Son La province and 4 at NOMAFSI Tay Bac Research Station. An overview of the locations of the field trials and farmers, researchers and extension staff involved is shown in Table 2.1.

The main objectives of trials were to: a) evaluate effectiveness of mini terraces and mulch for erosion prevention and the influence they have on maize growth and yield and; b) evaluate suitability of a range of legume crops for intercropping with maize and assess their impact on maize growth and yield. In addition to these main objectives, new hybrid and non-hybrid varieties of maize were evaluated in a subset of these experiments and the influence of maize planting density on yield was assessed in one experiment conducted at Tay Bac research station.

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 conducted after the 2010 trials 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 this report. Farmers were pivotal in all economic analyses presented in the report.

Table 2.1: Location of on-farm field trials and farmers, extension officers and researchers involved.

Province	Lai Chau				Son La			
District	Sin Ho		Tam Duong		Mai Son		Moc Chau	
Commune	Ta Ngao	Lang Mo	Giang Ma	Ban Bo	Na Ot	Chieng Chan	Muang Sang	Phieng Lung
Village	Lung Su Phin	Lang Mo	Giang Ma	Hung Phong	Na Ha	Ta Chan	La Nga	Pieng Sang
Number of experiments	1	1	2	2	2	2	3	2
Farmer Researcher ICM/erosion	1.Thao A Dao	1.Giang A Menh	1.Giang A Say 2.Giang A Vang	1.Nam 2.Nhuan 3.De 4.Chay 5.Quan	1 Pom 2. Lien	1. Khoi 2. Phan	1.Khang 2.Duc 3.Don	1.Thouong 2.Minh (F) 3.Senh 4.Sien
Researchers ICM/erosion	Thao, Huan		Thao, Huan		Minh, Nam, Huan		Minh, Nam, Thao, Phuong (TBU) Huan	
Provincial staff	Thuc				Ai			
District staff	Giang		Dung		Yeu		Hai, Quang	

The results of all experiments are presented per location in the order shown in Table 2.1. Experiments conducted at Tay Bac research station are presented at the end of the results section. Economic analysis of experimental practices and farmer practices outside experimental plots were conducted in Ta Ngao, Ban Bo and Na Ot, and are presented together with the results of relevant experiments.

3. General methodology

Experimental design, main cultivation activities and fertiliser application were specific for each experiment and they are presented in detail in the results section of the report. Assessments of maize growth and production and the statistical analysis of data were standardised across all experiments and are presented in this section.

3.1 Assessments of maize growth and production

The following assessments were conducted in each experiment:

1. Estimate of germination rate was done by randomly selecting in each replicate four rows that will 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. Record of development stages V3-4, V7, VT, R1, R3, R5 (see Table 3.1 for details about Development stages) and time of sowing and harvest.

3. Measurement of plant height and the height to the first cob (ear). Measurements 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%. Ten cobs were assessed 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)

Table 3.1: 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

3.2 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 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.

4. Experiments

4.0 Soil fertility on erosion experiment sites

Major soil macro and micro plant nutrients as well as soil acidity and salinity were assessed at one location in each of the four districts to establish a baseline of soil fertility.

4.0.1 Lang Mo - Erosion experiment site - Sin Ho District (22° 13′ 11″N, 103° 14′ 34″, 1325 m a.s.l.)

Results of soil analysis are presented in Table 4.0.1.1 and 4.0.1.2.

Soil acidity and salinity were within the range favourable for maize growth. The levels of carbon and C:N ratios were in the range that should not limit nitrogen uptake and maize yield. The levels of calcium were below optimal levels but are unlikely to be limiting for maize growth. Levels of phosphorus and potassium were below the acceptable limit. Levels of potassium were particularly low and it may be a limiting factor for achieving higher yield of maize. Application of phosphorus and potassium fertilizers will be necessary for continuous maize production. All micro elements were within the acceptable range.

Table 4.0.1.1: Soil acidity, salinity, carbon: nitrogen ratio and macro elements

Site	Depth	**pH**	**EC**	**TC**	**TN**	**C:N ratio**	**Col P**	**Ca**	**K**
			dS/m	Wt %	Wt %		mg/kg	cmol(+)/kg	cmol(+)/kg
Lang Mo	0-5	6.30	0.05	2.76	0.20	14.11	22.82	4.23	0.26
	5-25	5.95	0.04	2.38	0.16	15.03	18.55	3.25	0.15
	25-50	6.12	0.05	2.57	0.18	14.57	20.68	3.74	0.21
Acceptable limits		5 - 7.5	< 0.15	> 2	n/a	8 - 14	30 - 50	> 5	> 0.5

Table 4.0.1.2: Cation exchange capacity (CEC), secondary macro, and micro elements

Site	Depth	**Mg**	**Na**	**CEC**	**Ext S**	**Ext B**	**Ext Cu**	**Ext Fe**	**Ext Mn**	**Ext Zn**
		cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Lang Mo	0-5	2.23	0.04	6.76	15.80	1.16	2.58	56.90	126.63	2.99
	5-25	1.86	0.70	5.96	30.01	0.85	3.06	58.09	122.81	2.04
	25-50	2.05	0.37	6.36	22.90	1.00	2.82	57.49	124.72	2.52
Acceptable limits		> 1.6	< 1	< 10	> 5	> 0.5	> 0.5	> 20	> 5	> 0.5

4.0.2 Giang Ma - Erosion experiment site -Tam Duong District (22° 22′ 36″N, 103° 31′ 11″, 850m a.s.l.)

Results of soil analysis are presented in Table 4.0.2.1 and 4.0.2.2.

Soil pH levels were at or just below acceptable levels and care should be taken to avoid any further acidification of soil. Low magnesium levels in combination with low pH may warrant application of dolomite. There was no salinity problem at this location. Levels of carbon and C:N ratio were outside the optimum range but not to the extent that would be a major limitation for maize production. Levels of calcium were below optimal levels but are unlikely to be limiting. There was no phosphorus deficiency but levels of potassium were well below acceptable limits and potassium deficiency may be a limiting factor for higher maize yield. All micro elements were within the acceptable range.

Table 4.0.2.1: Soil acidity, salinity, carbon: nitrogen ratio and macro elements

Site	Depth	**pH**	**EC**	**TC**	**TN**	**C:N ratio**	**Col P**	**Ca**	**K**
			dS/m	Wt %	Wt %		mg/kg	cmol(+)/kg	cmol(+)/kg
Gieng Ma	0-5	5.04	0.06	1.84	0.11	17.95	35.86	1.26	0.26
	5-25	4.74	0.05	1.73	0.10	19.34	29.17	1.17	0.16
	25-50	5.04	0.04	1.39	0.10	14.77	31.22	0.96	0.21
Acceptable limits		5 - 7.5	< 0.15	> 2	n/a	8 - 14	30 -50	> 5	> 0.5

Table 4.0.2.2: Cation exchange capacity (CEC), secondary macro, and micro elements

Site	Depth	**Mg**	**Na**	**CEC**	**Ext S**	**Ext B**	**Ext Cu**	**Ext Fe**	**Ext Mn**	**Ext Zn**
		cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg
Gieng Ma	0-5	0.32	0.10	1.94	12.8	1.29	1.92	119.5	71.2	1.25
	5-25	0.21	0.08	1.62	12.1	0.86	2.21	113.0	44.9	1.04
	25-50	0.31	0.14	1.62	18.3	0.55	1.71	105.8	40.8	0.91
Acceptable limits		> 1.6	< 1	< 10	> 5	>0.5	>0.5	> 20	> 5	>0.5

4.0.3 Na Ot - Erosion experiment site - Mai Son District (21° 03′ 50″N, 103° 59′ 55″, 730 m a.s.l.)

Results of soil analysis are presented in Table 4.0.3.1 and 4.0.3.2.

Soil acidity and salinity were within the range favourable for maize growth. Levels of carbon and C:N ratio were in the range that should not limit nitrogen uptake and maize yield. The levels of calcium were below optimal levels but are unlikely to be limiting. Levels of phosphorus in the upper soil layer (up to 5 cm) were just below acceptable levels but levels at lower layers of soil were below the acceptable limits. Even though phosphorus levels may not be a major limitation the application of phosphorus fertiliser above the amount removed by the crop should be considered to improve soil fertility. The level of potassium in the layer above 25 cm was within acceptable levels so potassium fertiliser should be applied at concentrations to compensate for potassium taken by the crop. All micro elements were within the acceptable range.

Table 4.0.3.1: Soil acidity, salinity, carbon: nitrogen ratio and macro elements

Site	Depth (cm)	pH	EC	TC	TN	C:N ratio	Col P	Ca	K
			dS/m	Wt %	Wt %		mg/kg	cmol(+)/kg	cmol(+)/kg
Na Ot	0-5	5.33	0.04	3.01	0.20	15.42	26.29	1.44	0.68
	5-25	5.30	0.05	2.62	0.17	15.52	17.87	0.91	0.51
	25-50	4.93	0.02	1.57	0.12	13.02	11.41	0.24	0.31
Acceptable limits		5 - 7.5	< 0.15	> 2	n/a	8 - 14	30 - 50	> 5	> 0.5

Table 4.0.3.2: Cation exchange capacity (CEC), secondary macro, and micro elements

Site	Depth	Mg	Na	CEC	Ext S	Ext B	Ext Cu	Ext Fe	Ext Mn	Ext Zn
		cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Na Ot	0-5	0.98	0.01	3.11	13.9	1.43	1.86	113.8	22.9	1.15
	5-25	0.68	0.02	2.12	15.5	0.61	1.95	96.84	13.6	0.72
	25-50	0.23	0.00	0.78	19.6	0.34	1.42	46.41	8.14	0.36
Acceptable limits		> 1.6	< 1	< 10	> 5	> 0.5	>0.5	> 20	> 5	> 0.5

4.0.4 La Nga - Erosion experiment site - Moc Chau District (20° 50′ 31″N, 104° 35′ 24″, 790 m a.s.l.)

Results of soil analysis are presented in Table 4.0.4.1 and 4.0.4.2.

Soil pH levels were on or just below acceptable levels and care should be taken to avoid any further acidification of soil. There was no salinity problem at this location. Levels of carbon and C:N ratio were far outside the optimum range so care should be taken to prevent nitrogen deficiency. Levels of calcium were below optimal but are unlikely to be limiting. Phosphorus levels were high in the first 5 cm of soil but dropped dramatically in the 5-25 cm layer. Incorporation of phosphorus fertiliser deeper than 5 cm would improve soil fertility. Potassium levels were acceptable. All micro elements (except boron in the 25-50 cm layer) were within the acceptable range.

Table 4.0.4.1: Soil acidity, salinity, carbon: nitrogen ratio and macro elements

Site	Depth	**pH**	**EC**	**TC**	**TN**	**C:N ratio**	**Col P**	**Ca**	**K**
			dS/m	Wt %	Wt %		mg/kg	cmol(+)/kg	cmol(+)/kg
La Nga	0-5	5.37	0.05	1.64	0.04	42.99	41.51	2.50	0.77
	5-25	4.80	0.04	1.10	0.03	45.29	8.80	1.79	0.43
	25-50	4.74	0.05	1.35	0.13	10.75	6.95	1.74	0.49
Acceptable limits		5 - 7.5	< 0.15	> 2	n/a	8 - 14	30 - 50	> 5k	> 0.5

Table 4.0.4.2: Cation exchange capacity (CEC), secondary macro, and micro elements

Site	Depth	**Mg**	**Na**	**CEC**	**Ext S**	**Ext B**	**Ext Cu**	**Ext Fe**	**Ext Mn**	**Ext Zn**
		cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg	mg/ kg
La Nga	0-5	1.23	0.02	4.51	15.09	0.96	0.69	103.1	24.54	1.05
	5-25	1.67	0.01	3.91	42.96	0.45	0.60	35.39	9.33	0.70
	25-50	1.74	0.01	3.97	65.63	0.19	1.08	31.14	13.13	0.54
Acceptable limits		> 1.6	< 1	< 10	> 5	> 0.5	> 0.5	> 20	> 5	> 0.5

4.1 Lang Mo Village – Lang Mo Commune – Sin Ho District – Lai Chau Province

4.1.1 Experiment 1*:* Evaluation of a variety of soil conservation practices for erosion reduction

4.1.1.1 Experimental objectives

Objectives of the experiment have been:

1. Evaluation of longer term (3 years) effectiveness of different soil management practices for erosion reduction.

2. Evaluation of impacts of different soil management practices for erosion reduction on maize production.

4.1.1.2 Material and methods

4.1.1.2.1 Experimental design

The experiment was designed as a randomized complete block with 4 treatments and 3 replicates.

Treatments were:

1. Burn (T1)
2. Mini-terraces + Mulch (T2)
3. Pinto peanut (T3)(not implemented; effectively equal to T1)
4. Mulch (T4)

Each plot had an area of approximately 80 m^2, with each block having approximately 320 m^2 making a total experimental area of 1000 m^2 (see Fig 4.1.1.1).

Fig 4.1.1.1: Schematic map of the experiment

T1	T2	T3	T4
T2	T4	T1	T3
T3	T1	T2	T4

4.1.1.2.2 Main cultivation activities

1. Sowing (14/04/2010). Local (name unknown) maize variety was sown in trenches at a depth of 0.05 m with 4-5 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.5 m (0.7x0.5)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Mulch was applied a few days after sowing using a variety of plant materials brought from nearby uncultivated land.
4. First fertiliser dressing was applied on 01/05/10
5. First weeding was done on 01/05/10
6. Second fertiliser dressing was applied on 28/05/10
7. Second weeding was done on 28/05/10
8. Third weeding and soil cultivation was done when plants developed 13-14 leaves

4.1.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.1.1.1).

Table 4.1.1.1: Time and amount of fertilisers applied

Date/ Development stage	**Fertiliser**	**Amount/ha (kg/ha)**	**Price/kg (VND)**	**Cost/ha (VND)**
14/04/2010/ sowing	Bio-fertiliser Song Gianh*	750	2,700	2,025,000
	NPK 5:10:13	350	3,700	1,295,000
	Superphosphate (18%)	350	3,000	1,050,000
01/05/2010/V3-4	Urea (46% N)	110	6,800	748,000
	Kaliclorua (52% K)	80	14,000	1,120,000
28/05/2010/V7-8	Urea (46% N)	220	6,800	1,496,000
	Kaliclorua (52% K)	160	14,000	2,240,000
			Total cost	**9,974,000**

* Humus 23.5%, phosphorus 3%, humic acid 5.5% microelements

4.1.1.3 Results

4.1.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.1.1.2 and Table 4.1.1.3 respectively.

Table 4.1.1.2: Maize characteristics

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
Local variety	2.22 (0.02)	1.21 (0.01)	16.96 (0.17)	4.29 (0.04)	12.22 (0.22)	28.4 (0.87)	77	285

Table 4.1.1.3: Development of maize in Lang Mo

Development stage	**Burn**		**Mini-terraces**		**Mulch**	
	DAS[1]	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	**0**	14/04/10	**0**	14/04/10	**0**	14/04/10
V3-4	**17**	01/05/10	**17**	01/05/10	**17**	01/05/10
V7	**43**	27/05/10	**40**	24/05/10	**40**	24/05/10
VT	**79**	02/07/10	**76**	29/06/10	**76**	29/06/10
R1	**79**	02/07/10	**78**	01/07/10	**77**	30/06/10
R3	**104**	27/07/10	**104**	27/07/10	**102**	25/07/10
R5	**118**	10/08/10	**118**	10/08/10	**120**	12/08/10
Harvest	**131**	23/08/10	**131**	23/08/10	**131**	23/08/10

[1]DAS=Days after sowing

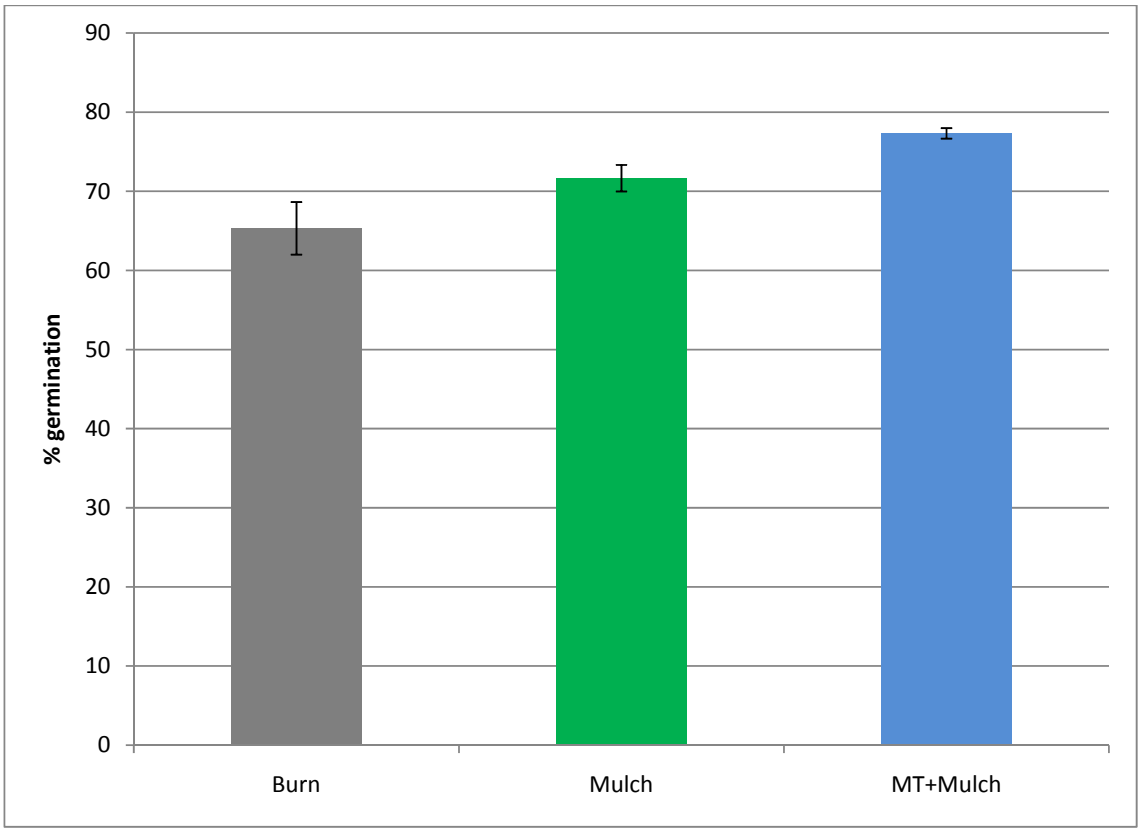
The average plant height of the local variety used in Lang Mo was within the range of average heights of modern hybrids but it was significantly lower than the height of local varieties at other experimental locations in Lai Chau province. However, the length of the cob and number of rows and seeds per row was lower than recorded in modern hybrids, indicating lower yield potential.

The development duration of the Lang Mo local variety was long (131 days) and it is consistent with the development length of local varieties in other locations in Lai Chau.

4.1.1.3.2 Germination rate

Germination rate was relatively low and ranged from 65 to 77 %. There were no significant differences in germination rate between treatments ($F_{2, 4}$ = 5.757, p=0.066) (Fig. 4.1.1.2).

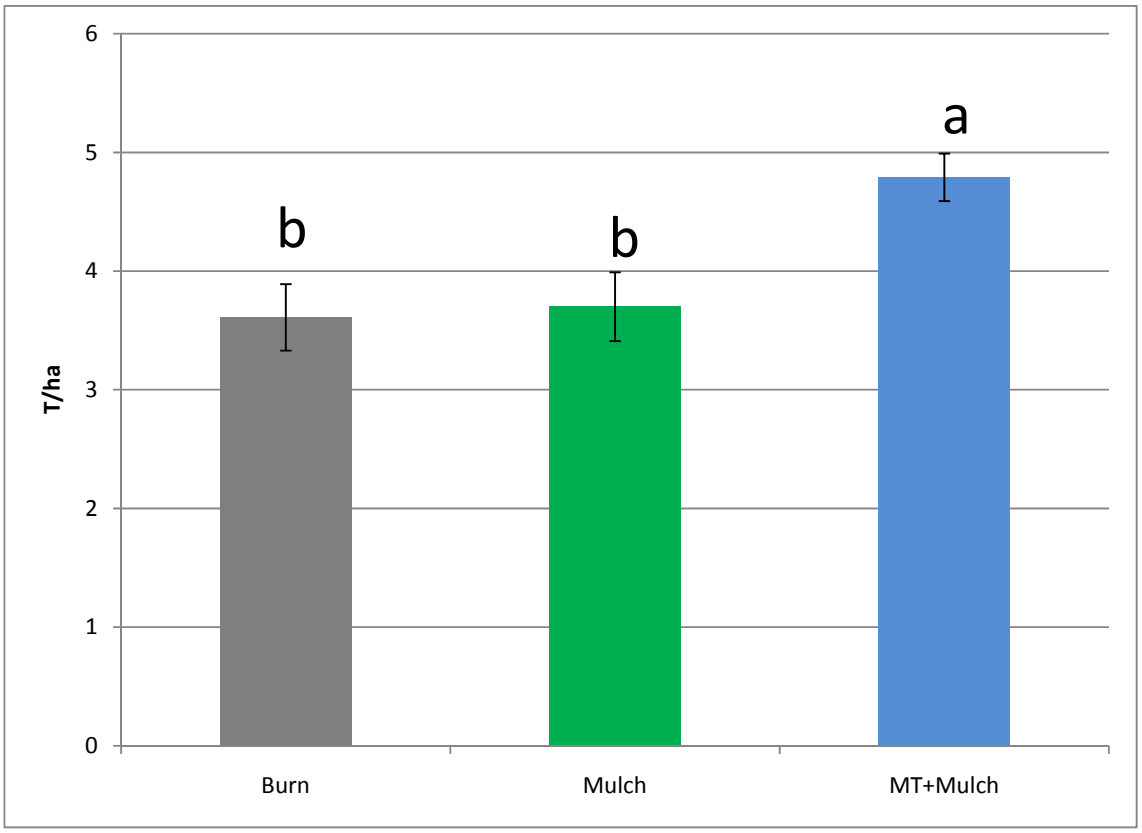
Figure 4.1.1.2: Germination rate of maize in different treatments



4.1.1.3.3 Yield

Yield ranged from 3.61 to 4.79 T/ha. There were significant differences in yield between treatments ($F_{2, 4}$ = 9.545, p=0.030). Yield of maize grown on mini terraces with mulch was significantly higher than yield of maize grown on soil where plant residues were burned before sowing ("burn") or where mulch was applied. There were no significant differences between treatments "burn" and "mulch". Results are presented in Figure 4.1.1.3.

Figure 4.1.1.3: Yield of maize in different treatments



4.1.1.4 Conclusions and comments

Use of mini terraces significantly increased yield but the increase of yield recorded seems to be too low to motivate farmers to significantly increase their labour input.

4.2 Lung Su Phin Village – Ta Ngao Commune – Sin Ho District – Lai Chau Province

4.2.1 Experiment 1: Impact of mulch on maize production

4.2.1.1 Experimental objectives

The objective of the experiment was to assess impact of mulch on maize production.

4.2.1.2 Material and methods

4.2.1.2.1 Experimental design

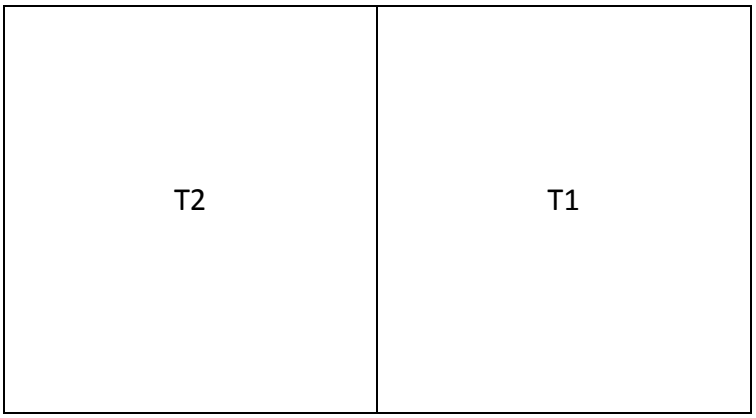
The experiment had 2 treatments and only 2 plots, one for each treatment. Since treatments were not replicated for all assessments 3 samples were randomly taken from 3 different locations within the plots and each sample was used as pseudo-replicate in statistical analysis.

Treatments were:

1. Mini-terrace (T1)
2. Mini-terraces + Mulch (T2)

Each plot had an area of approximately 500 m^2 making a total experimental area of 1000 m^2 (see figure 4.2.1.1).

Fig 4.2.1.1: Schematic map of the experiment



4.2.1.2.2 Main cultivation activities

1. Sowing (14/04/2010). Local (name unknown) maize variety was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Stubble from previous season was used as mulch.
4. First fertiliser dressing was applied on 30/04/10
5. First weeding was done on 30/04/10
6. Second fertiliser dressing was applied on 28/05/10
7. Second weeding was done on 28/05/10
8. Third weeding and soil cultivation was done when plants developed 13-14 leaves

4.2.1.2.3Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.2.1.1).

Table 4.2.1.1: Time and amount of fertilisers applied

Date/ Development stage	**Fertiliser**	**Amount/ha (kg/ha)**	**Price/kg (VND)**	**Cost/ha (VND)**
14/04/2010/ sowing	Bio-fertiliser Song Gianh	1000	2,700	2,700,000
	NPK 5:10:13	500	3,700	1,850,000
	Superphosphate (18%)	500	3,000	1,500,000
30/04/2010/V2-3	Urea (46% N)	110	6,800	748,000
	Kaliclorua (52% K)	80	14,000	1,120,000
28/05/2010/V8-10	Urea (46% N)	220	6,800	1,496,000
	Kaliclorua (52% K)	160	14,000	2,240,000
			Total cost	**11,654,000**

4.2.1.3 Results

4.2.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.2.1.2 and Table 4.2.1.3 respectively.

Table 4.2.1.2: Maize characteristics

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
Local variety	3.49 (0.01)	1.58 (0.02)	16.97 (0.23)	4.85 (0.10)	12.67 (0.42)	34.83 (0.79)	82	255

Table 4.2.1.3: Development of maize in Lung Su Phin

Development stage	**Mini-terraces + Mulch**		**Mini-terraces**	
	DAS	**Date**	**DAS**	**Date**
Sowing	0	14/04/10	0	14/04/10
V3-4	23	07/05/10	24	08/05/10
V7	43	27/05/10	45	29/05/10
VT	76	29/06/10	74	27/06/10
R1	79	02/07/10	77	30/06/10
R3	89	12/07/10	90	13/07/10
R5	126	18/08/10	123	15/08/10
Harvest	138	30/08/10	138	30/08/10

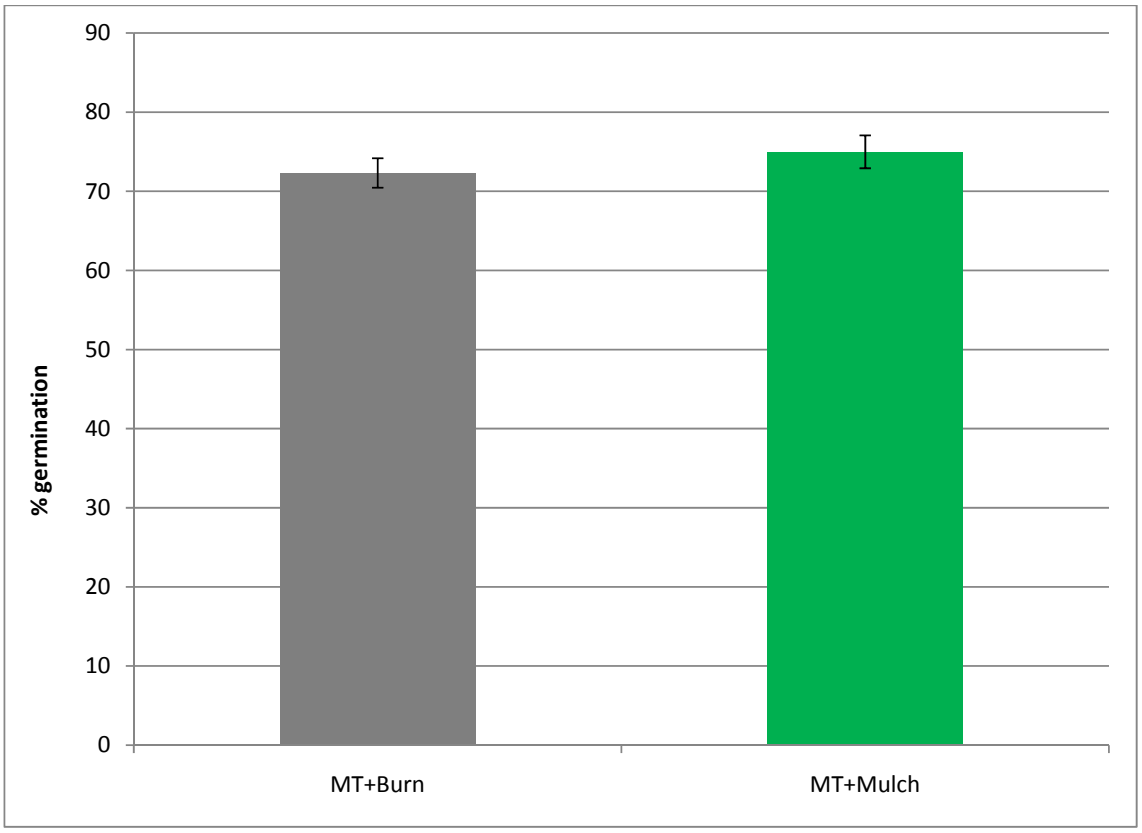
[1]DAS=Days after sowing

The local variety used in Lung Su Phin had very tall plants (average height 3.49 m), relatively short cobs and a high number of small seeds per row. The development duration was long (138 days).

4.2.1.3.2 Germination rate

Germination rate was relatively low and ranged from 72 to 75 %. There were no significant differences between treatments in germination rate ($F_{1, 2}$ = 0.842, p=0.456) (Fig. 4.2.1.2).

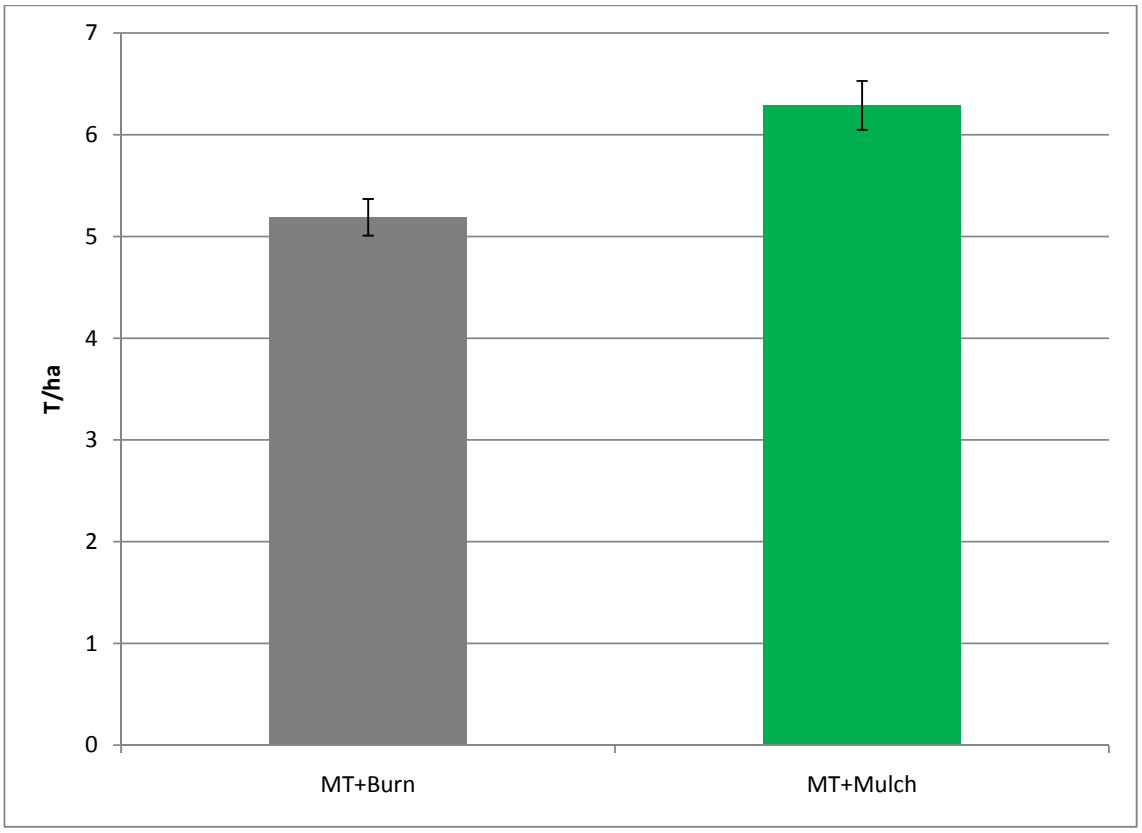
Figure 4.2.1.2: Germination rate of maize in different treatments



4.2.1.3.3 Yield

Yield ranged between 5.19 and 6.29 T/ha. There were no significant differences in yield between treatments ($F_{1, 2}$ = 9.461, p=0.091) (Fig. 4.2.1.3).

Figure 4.2.1.3: Yield of maize in different treatments



Farmer practice was not part of the experimental design but yield on neighbouring fields was estimated at 2.5 T, less than half the yield recorded in experimental plots.

4.2.1.3.4 Economic analysis

During participatory evaluation of the Lung Su Phin trial in August 2010, basic economic analysis was done. It compared existing farmer practice and experimental erosion management practices. Farmer researchers contributed to the estimation of work-days necessary for each production activity (Table 4.2.1.4), cost of inputs and income from maize sale (Table 4.2.1.5).

Results shows that use of mini-terraces with mulch or use of mini-terraces without mulch in combination with high use of fertilisers increased production of maize between 2 and 2.5 times in comparison to production on neighbouring farmers' fields. However, the high cost of inputs offset most of the benefits of higher production so there were no significant differences in profit (excluding the labour cost) between farmer practice and experimental treatment. If profit is expressed as profit relative to the labour input then profit was even lower for experimental treatments (166,510 VND and 129,866 VND per day of work for mini-terraces with mulch and mini-terraces without mulch respectively vs. 173,077 VND per day of work for farmer practice). Estimate of labour input is an approximation that should be more precisely measured in 2011.

Table 4.2.1.4: Estimate of labour input

Operation	**Mini-Terraces + Mulch**	**Mini-Terraces**	**Farmer practice**
Slashing organic material	14	14	14
Ploughing	0	0	12
Ploughing to make row	12	12	4
Sowing + fertilising at sowing	21	21	10
Care (weeding)	10	10	10
Fertilizing	3	3	0
Mulching	10		0
Harvesting	30	30	15
Total	**100**	**90**	**65**

Table 4.2.1.5: Economic analysis of the experiment

	Unit	Price (dong)	Amount			Value (dong)		
			Farmer	*MT+Mulch*	*MT*	*Farmer*	*MT+Mulch*	*MT*
Variety (local)	**kg**	0		**0**	**0**		0	0
Biofertiliser Song Gianh	**kg**	**2,700**	**0**	**1,000**	**1,000**	**0**	**2,700,000**	**2,700,000**
Urea	**kg**	**6,800**	**0**	**330**	**330**	**0**	**2,244,000**	**2,244,000**
NPK (5:10:3)	**kg**	**3,700**	**0**	**500**	**500**	**0**	**1,850,000**	**1,850,000**
Photphate	**kg**	**3,000**	**0**	**500**	**500**	0	**1,500,000**	**1,500,000**
Kaliclorua	**kg**	**14,000**	**0**	**240**	**240**	0	**3,360,000**	**3,360,000**
Pestiside			**0**	**0**	**0**	**0**	**0**	**0**
Labour	**day**		**68**	**100**	**90**			
I-INPUT COST						**0**	**11,654,000**	**11,654,000**
II-INCOME	**kg**	**4,500**	**2,500**	**6,290**	**5,187**	**11,250,000**	**28,305,000**	**23,342,000**
III-PROFIT	**dong**					**11,250,000**	**16,651,000**	**11,688,000**
IV PROFIT/ LABOUR DAY	**Dong/ day**					**173,077**	**166,510**	**129,866**

4.2.1.4 Conclusions and comments

Shifting maize production (=opening new production areas by cutting forest followed by short term use of land and long fallow afterwards) with no inputs currently remains an economically viable option for famers in Sin Ho. However, with the increase of population in the area this type of farming is not sustainable due to lack of availability of new areas of land. Farmers have awareness that further deforestation leads to water shortages through more rapid runoff and erosion and have restricted cultivation on steep slopes. This will eventually result in reduced fertility of arable land because the duration of fallow will continue to decrease. This experiment showed that use of mini-terraces and mulch together with high doses of fertiliser can more than double production and it prevents erosion. It also became apparent that the use of high doses of fertilisers alone within current farming practice is not economically viable. If higher use of fertiliser was adopted as part of a more comprehensive change in cultivation including use of hybrid varieties and high density planting, then yield increases of 4 to 5 times current levels may be possible, justifying higher investments and resulting in increased income for farmers. However, in the current socio-economic circumstances in Sin Ho production intensification is not possible because farmers do not have financial means to increase inputs, labour availability to apply high doses of fertilizer or technical knowledge to implement intensive cultivation. An approach that could be trialled in the future is use of mulch and low to moderate rate of fertilisers with current local varieties and planting density.

4.3 Giang Ma Village – Giang Ma Commune – Tam Duong District – Lai Chau Province

4.3.1 Experiment 1: Evaluation of new maize varieties

4.3.1.1 Experimental objectives

The objective of the experiment was to compare local variety of maize of unknown origin with hybrid maize KK 154 and Ha Giang varieties of maize: HG yellow primarily suitable for animal feed and HG white, a sticky maize variety for human consumption.

4.3.1.2 Material and methods

4.3.1.2.1 Experimental design

The experiment was designed as a randomized complete block with 4 treatments and 3 replicates.

Treatments were:

1. Ha Giang yellow (T1)
2. Ha Giang white (T2)
3. Hybrid KK 154 (T3)
4. Local variety (T4)

Each plot had an area of 125 m^2, with each block having an area of 500 m^2 making a total experimental area of 1500 m^2 (Fig. 4.3.1.1).

Fig 4.3.1.1: Schematic map of the experiment

T4	T3	T2
T1	T2	T4
T2	T4	T1
T3	T1	T3

4.3.1.2.2 Main cultivation activities

1. Sowing (09/04/2010). All maize varieties were sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Stubble from previous season was used as mulch.
4. First fertiliser dressing was applied on 01/05/10
5. First weeding was done on 01/05/10
6. Second fertiliser dressing was applied on 16/05/10
7. Second weeding was done on 16/05/10
8. Third weeding and soil cultivation was done when plants developed 13-14 leaves

4.3.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.3.1.1).

Table 4.3.1.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
09/04/2010/ sowing	Bio-fertiliser Song Gianh	670	2,700	1,809,000
	NPK 5:10:13	330	3,700	1,221,000
	Superphosphate (18%)	330	3,000	990,000
01/05/2010/V3-4	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	80	14,000	1,120,000
16/05/2010/V7-8	Urea (46% N)	200	6,800	1,360,000
	Kaliclorua (52% K)	160	14,000	2,240,000
			Total cost	**9,420,000**

4.3.1.3 Results

4.3.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.3.1.2 and Table 4.3.1.3 respectively.

Table 4.3.1.2: Maize characteristics

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
HG yellow	2.17 (0.05)	1.14 (0.04)	16.40 (0.83)	4.60 (0.15)	12.67 (0.67)	35.67 (1.20)	80	245
HG white	3.11 (0.03)	1.51 (0.07)	14.70 (1.19)	4.13 (0.15)	12.67 (0.67)	25.67 (2.73)	69	210
KK 154	2.13 (0.03)	1.18 (0.03)	16.50 (0.62)	5.00 (0.06)	15.33 (0.67)	34.67 (0.67)	75	220
Local variety	3.40 (0.08)	1.58 (0.03)	16.73 (0.72)	5.27 (0.23)	14.67 (1.33)	30.00 (2.65)	66	280

Table 4.3.1.3: Development of maize in Giang Ma

Development Stage	**KK154**		**Local**		**Yellow HG**		**White HG**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	**0**	09/04/10	**0**	09/04/10	**0**	09/04/10	**0**	09/04/10
V3-4	**21**	30/04/10	**22**	01/05/10	**22**	01/05/10	**19**	28/04/10
V7	**40**	19/05/10	**42**	21/05/10	**41**	20/05/10	**37**	16/05/10
VT	**65**	13/06/10	**76**	24/06/10	**75**	23/06/10	**62**	10/06/10
R1	**67**	15/06/10	**79**	27/06/10	**77**	25/06/10	**64**	12/06/10
R3	**91**	09/07/10	**98**	16/07/10	**96**	14/07/10	**74**	22/06/10
R5	**104**	22/07/10	**108**	26/07/10	**110**	28/07/10	**87**	05/07/10
Harvest	**115**	02/08/10	**115**	02/08/10	**115**	02/08/10	**93**	11/07/10

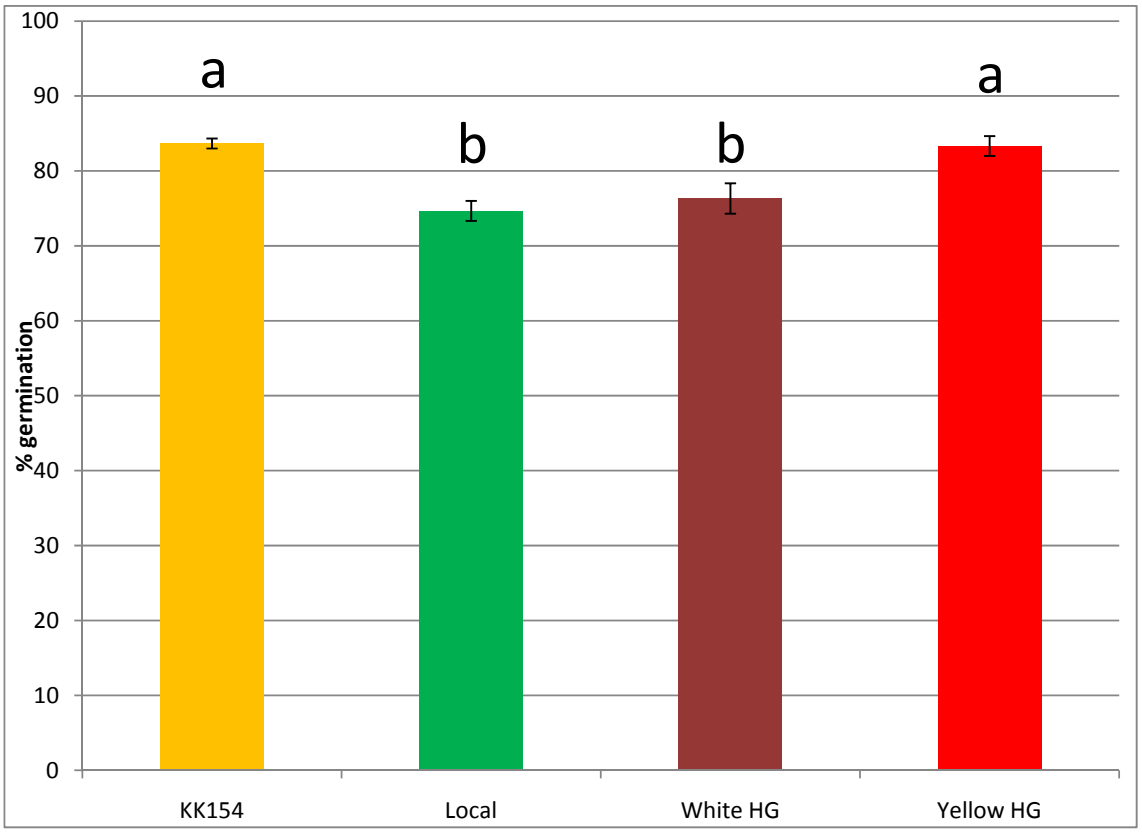
[1]DAS=Days after sowing

The local variety grown in Giang Ma is significantly taller than new varieties trialled. All varieties had medium duration of development except for Ha Giang White, which had a short development time.

4.3.1.3.2 Germination rate

Germination rate ranged from 75 to 84 %. There were significant differences between treatments in germination rate ($F_{3, 6}$ = 8.694, p=0.013) (Fig. 4.3.1.2). Maize variety HG Yellow and hybrid KK 154 had statistically significantly higher germination rate than local variety and HG white. There were no significant differences between other varieties.

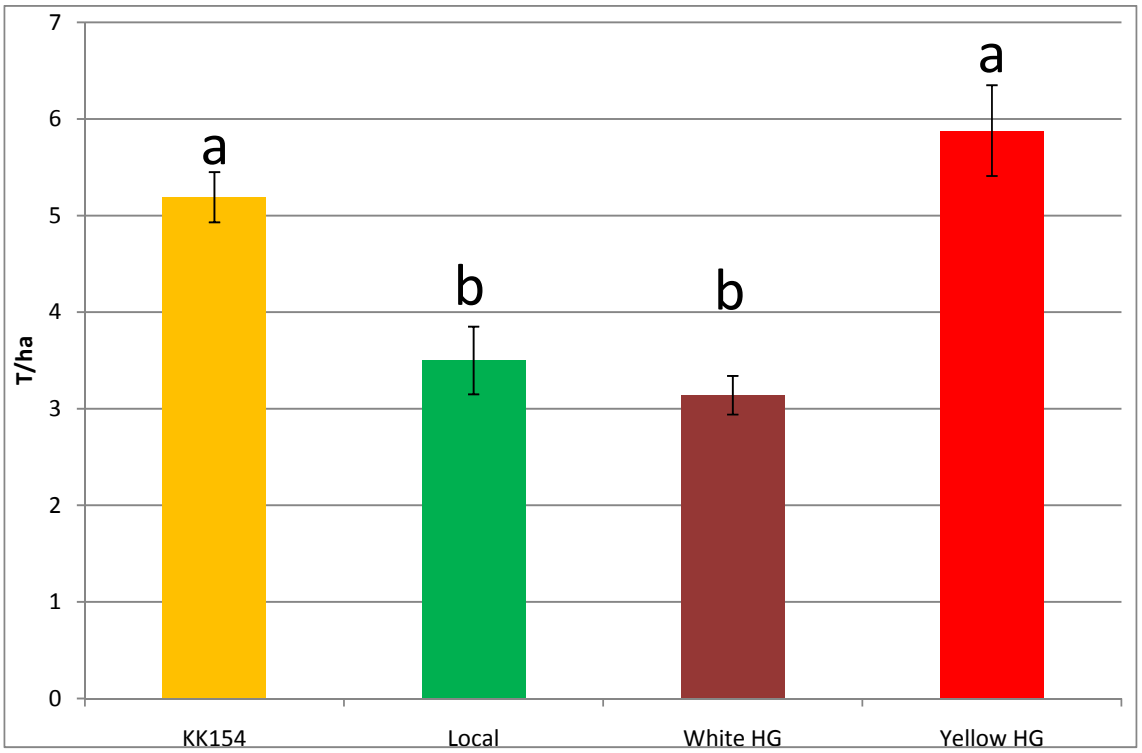
Figure 4.3.1.2: Germination rate of maize in different treatments



4.3.1.2.3 Yield

Yield ranged between 3.14 and 5.88 T/ha. There were significant differences in yield between treatments ($F_{3, 6}$ = 17.018, p=0.002). Maize variety HG Yellow and hybrid KK 154 had statistically significantly higher yield than local variety and HG white. There were no significant differences between other varieties (Fig 4.3.1.3).

Figure 4.3.1.3: Yield of maize in different treatments



4.3.1.4 Conclusions and comments

Participatory evaluation of the trial established that Ha Giang Yellow variety was preferred by both farmers because it has higher yield than the local variety and it keeps better in storage. Better storage capability may be partly explained by much higher percentage of seed weight relative to total weight of the cob (80% for HG Yellow and only 66% for local variety). Farmers plan to introduce Ha Giang Yellow variety on a larger area.

Ha Giang White had the same yield as the local variety but according to farmers it has better cooking characteristics and better taste so farmers will plant small areas with HG White for their own consumption.

Hybrid variety KK 154 did not show any advantage in comparison to HG Yellow and farmers will not use it in their fields.

4.3.2 Experiment 2: Evaluation of a variety of soil conservation practices for reduction of erosion

4.3.2.1 Experimental objectives

Objectives of the experiment have been:

1. Evaluate longer term (3 years) effectiveness of different soil management practices for erosion reduction.

2. Evaluate impacts of different soil management practices for erosion reduction on maize production.

4.3.2.2 Material and methods

4.3.2.2.1 Experimental design

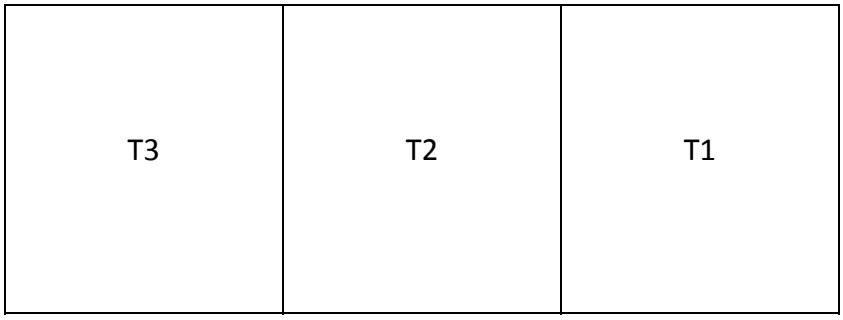
The experiment had 3 treatments and only 3 plots, one for each treatment. Since treatments were not replicated for all assessments 3 samples were randomly taken from 3 different locations within the plots and each sample was used as pseudo-replicate in statistical analysis.

Treatments were:

1. Mini-terraces and Burn (T1)
2. Mini-terraces and pinto peanut (T2) (Pinto peanut was sown more than month after sowing of maize but establishment was unsuccessful. Because there were no pinto peanut grown in experimental plot this treatment can be considered similar to treatment T1.
3. Mini-terraces and mulch (T3)

Each plot had an area of 330 m^2 that makes total experimental area of approximately 1000 m^2 (Fig 4.3.2.1).

Fig 4.3.2.1: Schematic map of the experiment



4.3.2.2.2 Main cultivation activities

1. Sowing (11/04/2010). Local (name unknown) maize variety was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Stubble from previous season was used as mulch.
4. First fertiliser dressing was applied on 01/05/10
5. First weeding was done on 01/05/10
6. Second fertiliser dressing was applied on 16/05/10
7. Second weeding was done on 16/05/10
8. Third weeding and soil cultivation was done when plants developed 13-14 leaves

4.3.2.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.3.2.1).

Table 4.3.2.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
11/04/2010/ sowing	Bio-fertiliser Song Gianh	750	2,700	2,025,000
	NPK 5:10:13	350	3,700	1,295,000
	Superphosphate (18%)	350	3,000	1,050,000
01/05/2010/V2-3	Urea (46% N)	110	6,800	748,000
	Kaliclorua (52% K)	80	14,000	1,120,000
16/05/2010/V6-7	Urea (46% N)	220	6,800	1,496,000
	Kaliclorua (52% K)	160	14,000	2,240,000
			Total cost	**9,974,000**

4.3.2.3 Results

4.3.2.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.3.2.2 and Table 4.3.2.3 respectively.

Table 4.3.2.2: Maize characteristics

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
Local variety	2.57 (0.04)	1.18 (0.05)	17.40 (0.61)	4.53 (0.06)	14.00 (0.33)	33.00 (1.19)	70	250

Table 4.3.2.3: Development of maize in Giang Ma

Development Stage	MT + Burn		MT + Burn (P)		MT + Mulch	
	DAS	Date	DAS	Date	DAS	Date
Sowing	**0**	15/04/10	**0**	15/04/10	**0**	15/04/10
V3-4	**19**	04/05/10	**19**	04/05/10	**19**	04/05/10
V7	**42**	27/05/10	**41**	26/05/10	**39**	24/05/10
VT	**76**	30/06/10	**75**	29/06/10	**73**	27/06/10
R1	**77**	01/07/10	**77**	01/07/10	**74**	28/06/10
R3	**101**	25/07/10	**101**	25/07/10	**98**	22/07/10
R5	**108**	01/08/10	**108**	01/08/10	**108**	01/08/10
Harvest	**119**	12/08/10	**119**	12/08/10	**119**	12/08/10

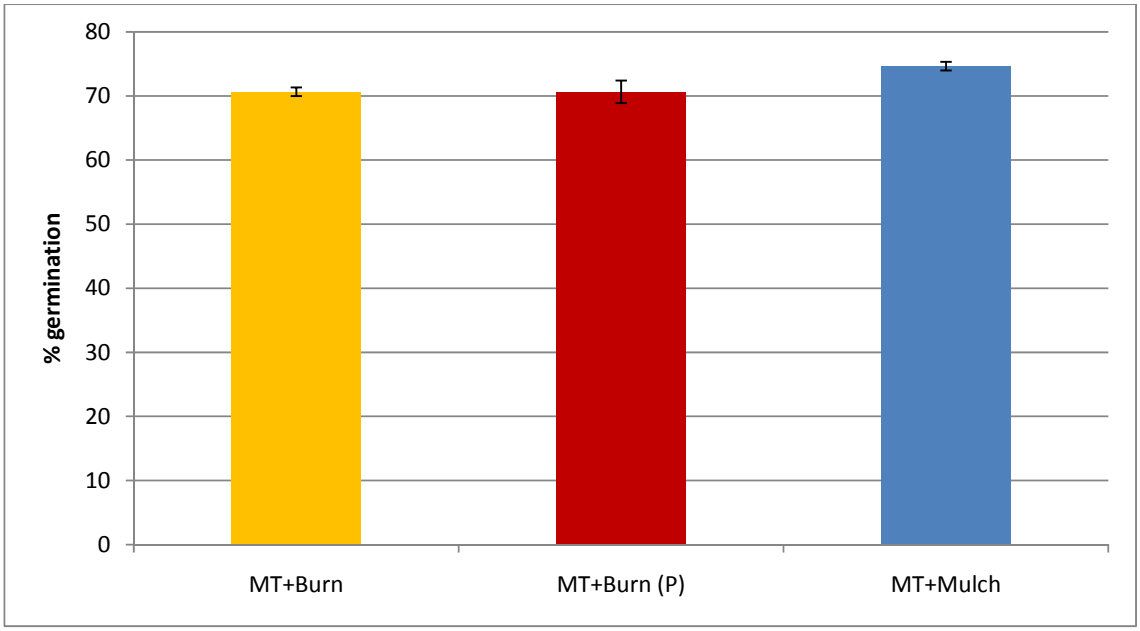
[1]DAS=Days after sowing

The local variety in this experiment was much shorter than in Experiment 4.3.1, but because all other characteristics including yield are similar it is very likely that the local varieties used in experiment 4.3.1 and 4.3.2 are the same and that differences may be due to maize being grown on a slope in experiment 4.3.2 and on a flat part of the valley in experiment 4.3.1.

4.3.2.3.2 Germination rate

Germination rate ranged from 71 to 75 %. There were no significant differences between treatments in germination rate ($F_{2, 4} = 4.00$, $p=0.111$) (Fig. 4.3.2.2).

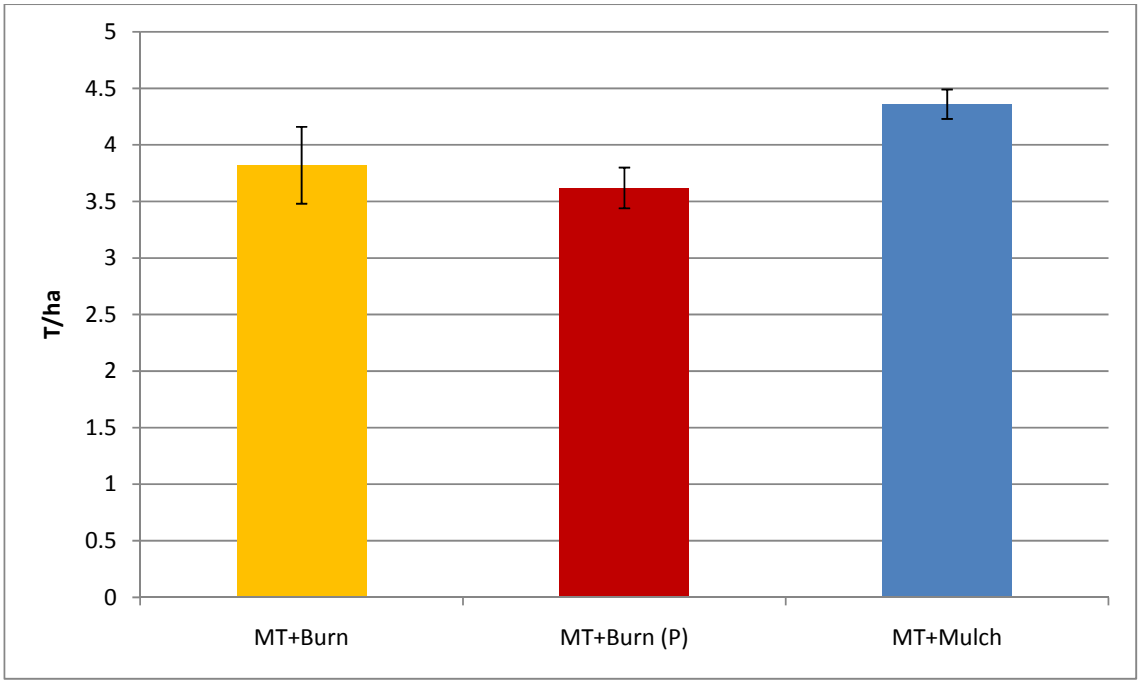
Figure 4.3.2.2: Germination rate of maize in different treatments



4.3.2.3.3 Yield

Yield ranged between 3.62 and 4.36 T/ha. There were no significant differences in yield between treatments ($F_{2, 4}$ = 2.066, p=0.242) (Fig. 4.3.2.3).

Figure 4.3.2.3: Yield of maize in different treatments



4.3.2.4 Conclusions and comments

This experiment was established too late for Pinto peanut to be sown. Not much can be concluded other than it seems that addition of mulch has a positive impact on maize yield. The main benefit from this experiment is the establishment of a good relationship with farmers which could be beneficial for future experiments.

4.4 Hung Phong Village – Ban Bo Commune – Tam Duong District – Lai Chau Province

4.4.1 Experiment 1: Evaluation of new maize varieties and intercropping with black beans

4.4.1.1 Experimental objectives

The objective of the experiment was to:

1. Compare three hybrid varieties of maize

2. Assess the impact of black beans on maize productivity.

4.4.1.2 Material and methods

4.4.1.2.1 Experimental design

The experiment was designed as a randomized complete block with 4 treatments and 4 replicates. Treatments were:

1. CP 989 (T1)
2. Bioseed 9698 (T2)
3. CP 999 (T3)
4. CP 999 intercropped with black beans (T4)

Each plot had an area of 250 m^2, with each block having an area of 1000 m^2 making a total experimental area of 4000 m^2. Each block was assigned to a different farmer researcher (Fig 4.4.1.1)

Fig 4.4.1.1: Schematic map of the experiment

* Pham Dinh Nam

T4	T3	T2	T1

* Nguyen Van Nhuan

T4	T3	T2	T1

* Nguyen Dinh De

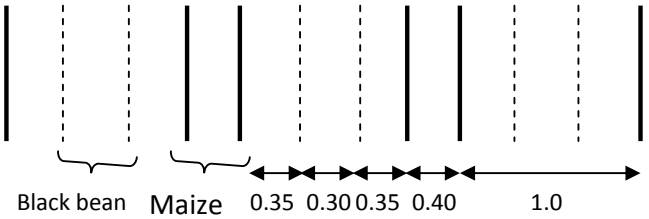
T4	T3	T2	T1

* Nguyen Dinh Chay

T4	T3	T2	T1

4.4.1.2.2 Main cultivation activities

1. Sowing (12/04/2010). All maize varieties were sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3).
2. In treatment T4 (intercropping) maize was sown in strips of two rows of maize with a narrow spacing of 0.4 m. Spacing between 2 strips was 1 m. Black bean was sown in two rows 0.3 m apart into the 1m-space between two maize strips (see diagram below).



3. Fertiliser was added only to maize at the time of sowing in same trenches as seeds but at a depth of 0.15 m
4. First fertiliser dressing was applied on 30/04/10
5. First weeding was done on 30/04/10
6. Second fertiliser dressing was applied on 15/05/10
7. Second weeding was done on 15/05/10
8. Third weeding and soil cultivation was done when plants developed 13-14 leaves

4.4.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.4.1.1).

Table 4.4.1.1: Time and amount of fertilisers applied

Date/ Development stage	**Fertiliser**	**Amount/ha (kg/ha)**	**Price/kg (VND)**	**Cost/ha (VND)**
12/04/2010/ sowing	Bio-fertiliser Song Gianh	1,000	2,700	2,700,000
	NPK 5:10:13	500	3,300	1,650,000
	Superphosphate (18%)	500	3,100	1,550,000
30/04/2010/V3-4	Urea (46% N)	110	7,600	836,000
	Kaliclorua (52% K)	80	14,000	1,120,000
15/05/2010/V6-7	Urea (46% N)	220	7,600	1,672,000
	Kaliclorua (52% K)	160	14,000	2,240,000
			Total cost	11,768,000

4.4.1.3 Results

4.4.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.4.1.2 and Table 4.4.1.3 respectively.

Table 4.4.1.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
CP 989	2.50 (0.03)	1.13 (0.02)	23.18 (0.40)	4.88 (0.09)	14.50 (0.50)	42.25 (1.38)	81	270
Bioseed 9698	2.21 (0.02)	1.18 (0.01)	16.38 (1.40)	4.80 (0.04)	13.50 (0.50)	35.50 (1.71)	73	272
CP 999	2.58 (0.02)	1.30 (0.02)	21.55 (0.90)	4.90 (0.09)	15.50 (0.50)	34.50 (1.19)	80	305
CP999+beans	2.66 (0.02)	1.33 (0.07)	22.20 (1.01)	4.68 (0.18)	15.50 (0.50)	35.50 (1.85)	79	301

Table 4.4.1.3: Development of maize in Ban Bo

Development Stage	**CP999+beans**		**Cp999**		**Bio9698**		**CP989**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	**0**	12/04/10	**0**	12/04/10	**0**	12/04/10	**0**	12/04/10
V3-4	**18**	30/04/10	**18**	30/04/10	**17**	29/04/10	**18**	30/04/10
V7	**36**	18/05/10	**36**	18/05/10	**35**	17/05/10	**34**	16/05/10
VT	**63**	14/06/10	**62**	13/06/10	**61**	12/06/10	**62**	13/06/10
R1	**66**	17/06/10	**64**	15/06/10	**62**	13/06/10	**67**	18/06/10
R3	**78**	29/06/10	**79**	30/06/10	**81**	02/07/10	**78**	29/06/10
R5	**101**	22/07/10	**104**	25/07/10	**103**	24/07/10	**103**	24/07/10
Harvest	**106**	27/07/10	**106**	27/07/10	**106**	27/07/10	**106**	27/07/10

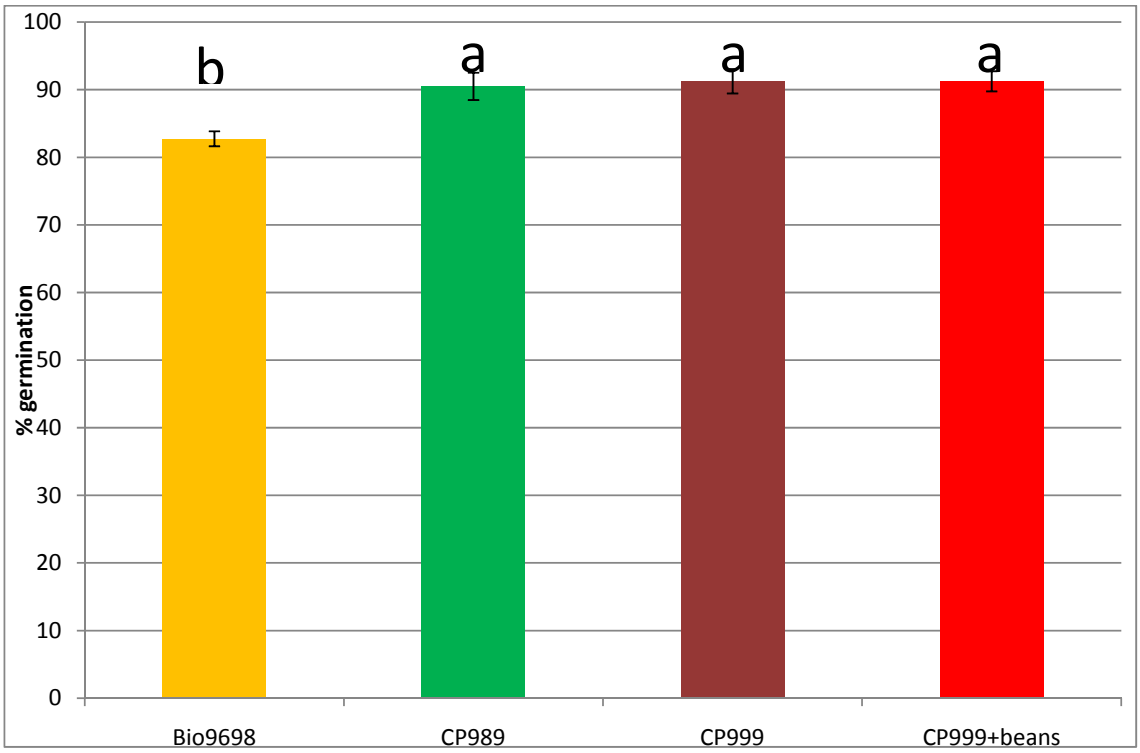
[1]DAS=Days after sowing

All maize hybrids tested had similar morphological characteristics and development times. It seems, however, that variety CP999 had larger kernels.

4.4.1.3.2 Germination rate

Germination rate ranged from 83 to 91 %. There were significant differences between treatments in germination rate ($F_{3, 9}$ = 6.261, p=0.014) (Fig. 4.4.1.2). Maize variety Bio 9698 had a statistically significantly lower germination rate than other varieties. There were no significant differences between other varieties.

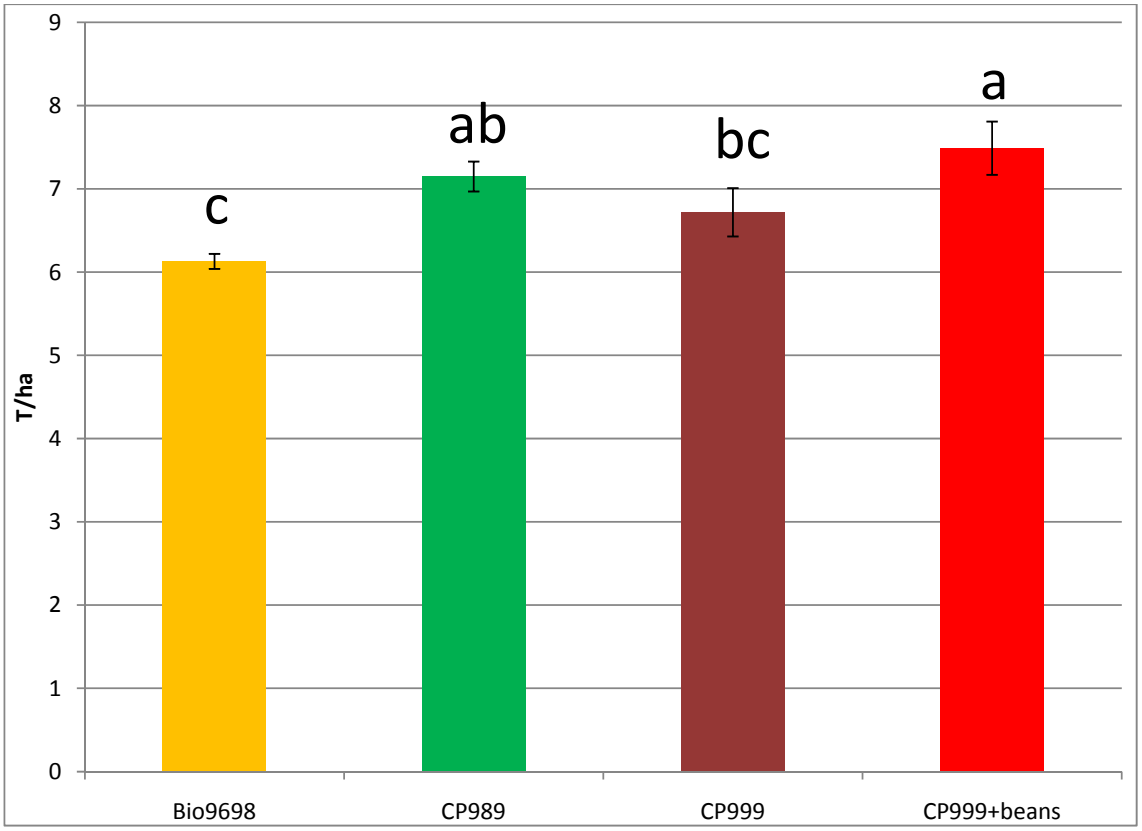
Figure 4.4.1.2: Germination rate of maize in different treatments



4.4.1.3.3 Yield

Yield ranged between 6.13 and 7.49 T/ha. There were significant differences in yield between treatments ($F_{3, 9}$ = 8.161, p=0.006) (Fig 4.4.1.3). Maize variety CP999 intercropped with black bean had statistically significantly higher yield than variety CP999 planted as a mono-crop and Bio698. Variety CP989 has significantly higher yield than Bio9698. There were no significant differences between other varieties.

Figure 4.4.1.3: Yield of maize in different treatments



Farmer practice was not part of the experimental design but yield on neighbouring fields of variety CP999 was estimated at 4 T/ha, less than a half of the yield recorded in experimental plots.

4.4.1.3.4 Economic analysis

Basic economic analysis of Ban Bo trial number 1 was done during participatory evaluation in September 2010. It compared existing farmer practice with improved management practices included in the experiment. Farmer researchers contributed to the estimation of the number of work-days used in production of maize in experimental plots (100 days), their own fields (84 days) and the cost of inputs and income from maize sales (Table 4.4.1.4).

Results shows that better use of fertilisers and control of pests and diseases in experimental plots increased production of maize by 68% and resulted in increased profits (excluding cost of labour) of 34%.

There was only a slight increase in labour inputs so profits expressed as profit relative to the labour input for CP999 experimental treatment was higher than for CP999 in farmer fields (178,720 VND per day of work for experimental treatment vs. 158,452 VND per day of work for farmer practice).

Table 4.4.1.4: Economic analysis of the experiment

	Unit	Cost (dong)	Amount		Value (dong)	
			Farmer	*Project*	*Farmer*	*Project*
Variety (CP999)	kg	55,000	17	0		
Variety (CP999)	kg	55,000	0	17		
Biofertiliser Song Gianh	kg	2,700	0	1,000	0	2,700,000
Ure	kg	7,600	400	330	3,040,000	2,508,000
NPK (5:10:3)	kg	3,300	500	500	1,650,000	1,650,000
Photphate	kg	3,100	0	500	0	1,550,000
Kaliclorua	kg	14,000	0	240	0	3,360,000
Pestiside						600,000
Labour	day		84	100		
I-INPUT COST					4,690,000	12,368,000
II-INCOME	kg	4,500	4,000	6,720	18,000,000	30,240,000
III-PROFIT	dong				13,310,000	17,872,000
IV PROFIT/ LABOUR DAY	Dong/ day				158,452	178,720

4.4.1.4 Conclusions and comments

Results show that intercropping with legumes (black bean) had a positive impact on maize yield. Total loss of the bean crop due to diseases at the end of growing season indicates that producing a bean crop during the rainy season may require high use of fungicides. An IPM program for legumes intercropped with maize should be developed and the experiment should be repeated in 2011 before more meaningful conclusions about benefits of intercropping with legumes can be drawn.

Economic analysis indicates that farmers used significant amounts of fertiliser without substantial increase in yield, resulting in only moderate profitability. Improved crop management that includes more frequent use of smaller quantities of nitrogen fertilisers (farmers add nitrogen only once and project treatments 2 times), mulching and pest and disease management can significantly improve farmers production and income.

4.4.2 Experiment 2: Influence of intercropping with black beans on maize productivity

4.4.2.1 Experimental objectives

The objective of the experiment was:

1. Evaluate the influence of intercropping with black beans on maize productivity

4.4.2.2 Materials and methods

4.4.2.2.1 Experimental design

The experiment was a randomised complete block design with 2 treatments and 3 replicates.

Treatments were:

1. KK154 (T1)
2. KK154 intercropped with black beans (T2)

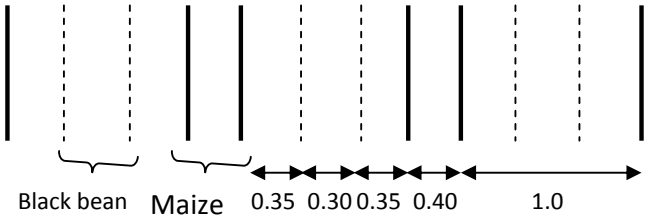
Each plot had an area of 170 m^2, with each block having an area of 340 m^2 making a total experimental area of approximately 1000 m^2 (Fig 4.4.2.1).

Fig 4.4.2.1: Schematic map of the experiment

T1	T2	T1
T2	T1	T2

4.4.2.2.2 Main cultivation activities

1. Sowing (12/04/2010). Maize was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. In treatment T2 (intercropping) maize was sown in strips of two rows of maize with a narrow spacing of 0.4 m. Spacing between 2 strips was 1 m. Black bean was sown in two rows 0.3 m apart into the 1m-space between two maize strips (see diagram below).



3. Fertiliser was added only to maize at the time of sowing in same trenches as seeds but at a depth of 0.15 m
4. First fertiliser dressing was applied on 30/04/10
5. First weeding was done on 30/04/10
6. Second fertiliser dressing was applied on 15/05/10
7. Second weeding was done on 15/05/10
8. Third weeding and soil cultivation was done when plants developed 13-14 leaves

4.4.2.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.4.2.1).

Table 4.4.2.1: Time and amount of fertilisers applied

Date/ Development stage	**Fertiliser**	**Amount/ha (kg/ha)**	**Price/kg (VND)**	**Cost/ha (VND)**
12/04/2010/ sowing	Bio-fertiliser Song Gianh	1,000	2,700	2,700,000
	NPK 5:10:13	500	3,700	1,850,000
	Superphosphate (18%)	500	3,000	1,500,000
30/04/2010/V3-4	Urea (46% N)	110	6,800	748,000
	Kaliclorua (52% K)	80	14,000	1,120,000
15/05/2010/V7-8	Urea (46% N)	220	6,800	1,496,000
	Kaliclorua (52% K)	160	14,000	2,240,000
			Total cost	11,654,000

4.4.2.3 Results

4.4.2.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.4.2.2 and Table 4.4.2.3 respectively.

Table 4.4.2.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
KK154	2.19 (0.01)	1.17 (0.10)	19.28 (0.67)	5.22 (0.05)	17.00 (0.45)	38.67 (0.72)	70	220

Table 4.4.2.3: Development of maize in Ban Bo

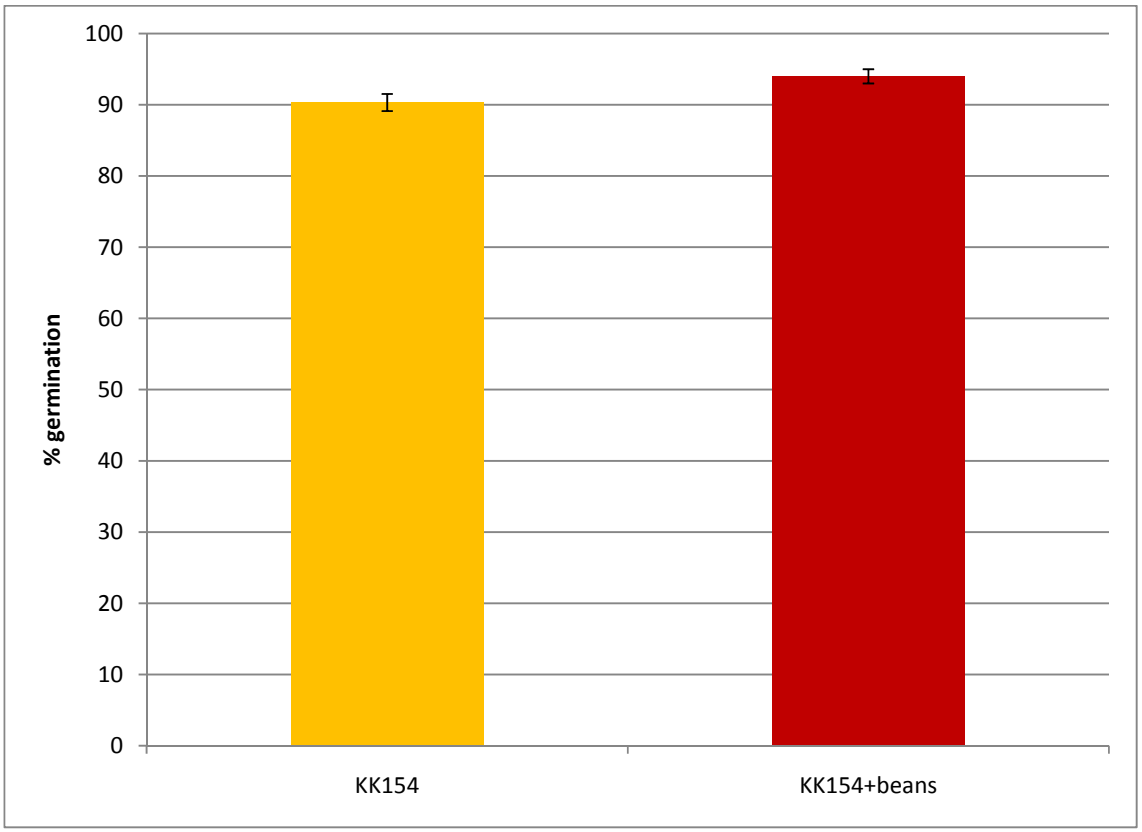
Development Stage	**KK154**		**KK154+beans**	
	Day	**Date**	**Day**	**Date**
Sowing	**0**	11/04/10	**0**	11/04/10
V3-4	**19**	30/04/10	**19**	30/04/10
V7	**35**	16/05/10	**35**	16/05/10
VT	**58**	08/06/10	**59**	09/06/10
R1	**60**	10/06/10	**61**	11/06/10
R3	**83**	03/07/10	**84**	04/07/10
R5	**108**	28/07/10	**110**	30/07/10
Harvest	**112**	01/08/10	**112**	01/08/10

[1]DAS=Days after sowing

4.4.2.3.2 Germination rate

Germination rate ranged from 90 to 94 %. There were no significant differences between treatments in germination rate ($F_{1, 2} = 4.32$, p=0.173) (Fig. 4.4.2.2).

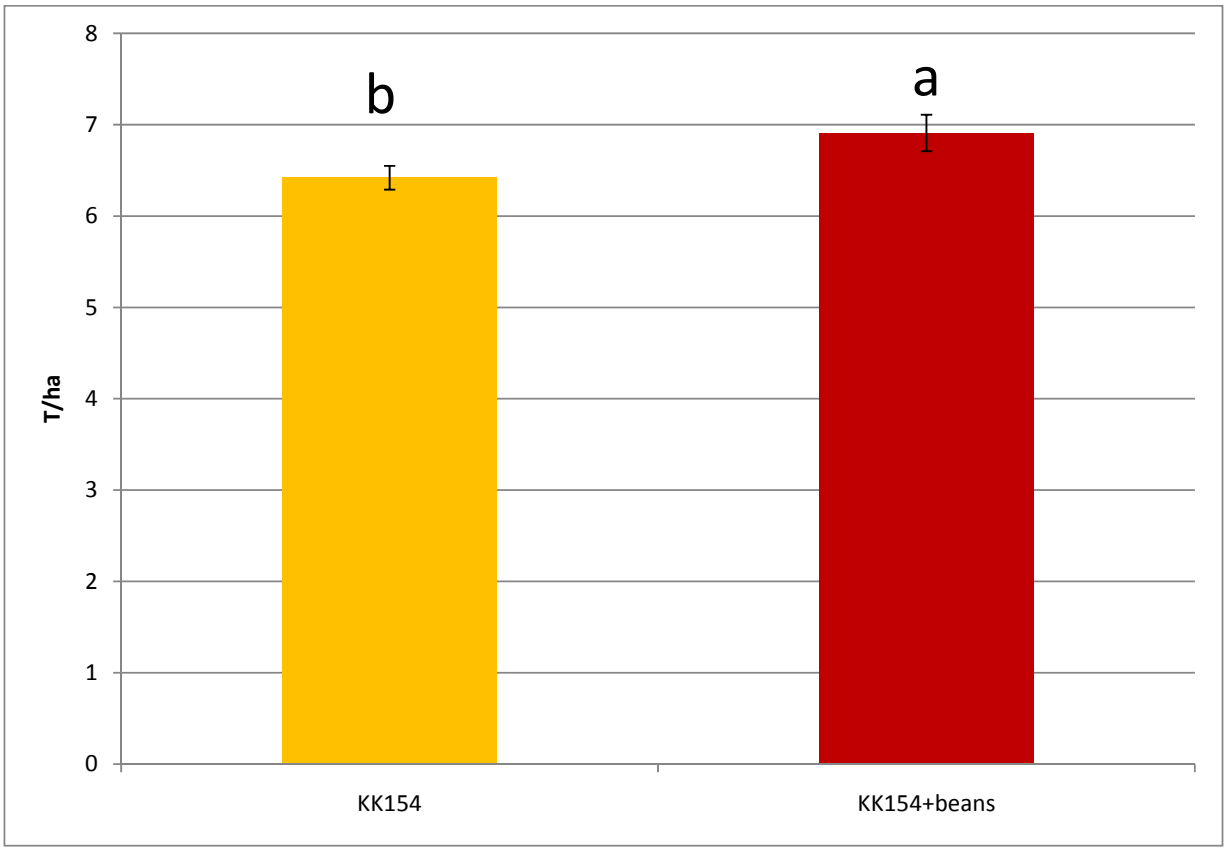
Figure 4.4.2.2: Germination rate of maize in different treatments



4.4.2.3.3 Yield

Yield ranged between 6.42 and 6.91 T/ha. There were significant differences in yield between treatments ($F_{1, 2}$ = 34.23, p=0.028) (Fig. 4.4.2.3). Yield of maize was higher when intercropped with black bean than when planted as a monocrop.

Figure 4.4.2.3: Yield of maize in different treatments



4.4.2.4 Conclusions and comments

Similar to previous experiment 4.4.1, the legume crop was destroyed by diseases at the end of the season before beans could be harvested. However, the experiment reconfirmed that legumes have a beneficial effect on maize growth which was reflected in higher yield.

4.5 Na Ha Village – Na Ot Commune – Mai Son District – Son La Province

4.5.1 Experiment 1: Evaluation of mini-terraces and mulch as soil conservation practices for erosion reduction

4.5.1.1 Experimental objectives

Objectives of the experiment have been:

1. Evaluation of longer term (3 years) effectiveness of different soil management practices for erosion reduction.

2. Evaluation of impacts of different soil management practices for erosion reduction on maize production.

4.5.1.2 Material and methods

4.5.1.2.1 Experimental design

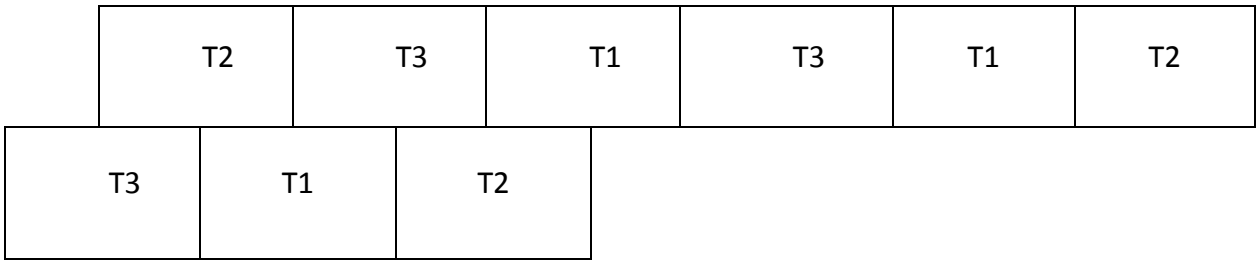
The experiment was designed as a randomized complete block with 3 treatments and 3 replicates.

Treatments were:

1. Burn (T1)
2. Mini-terraces + Mulch (T2)
3. Mulch (T3)

Each plot had an area of approximately 110 m^2, with each block having approximately 330 m^2 making a total experimental area of approximately 1000 m^2 (Fig. 4.5.1.1).

Fig 4.5.1.1: Schematic map of the experiment



4.5.1.2.2 Main cultivation activities

1. Sowing (18/04/2010). The maize variety LVN99 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Mulch was applied a few days after sowing using a variety of plant materials brought from nearby uncultivated land.
4. First fertiliser dressing was applied on 28/04/10
5. First weeding was done on 28/04/10
6. Second fertiliser dressing was applied on 31/05/10
7. Second weeding was done on 31/05/10
8. Third fertiliser dressing was applied on 10/06/10
9. Third weeding was done on 10/06/10

4.5.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.5.1.1).

Table 4.5.1.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
18/04/2010	Superphosphate (18%)	500	3,000	1,500,000
28/04/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
31/05/2010/V8-10	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
10/06/2010/V12-13	Urea (46% N)	120	6,800	816,000
	Kaliclorua (52% K)	60	14,000	840,000
			Total cost	**5,916,000**

4.5.1.3 Results

4.5.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.5.1.2 and Table 4.5.1.3 respectively.

Table 4.5.1.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN99	2.03 (0.01)	0.99 (0.07)	19.29 (0.23)	3.51 (0.07)	13.46 (0.13)	32.67 (0.35)	76	310

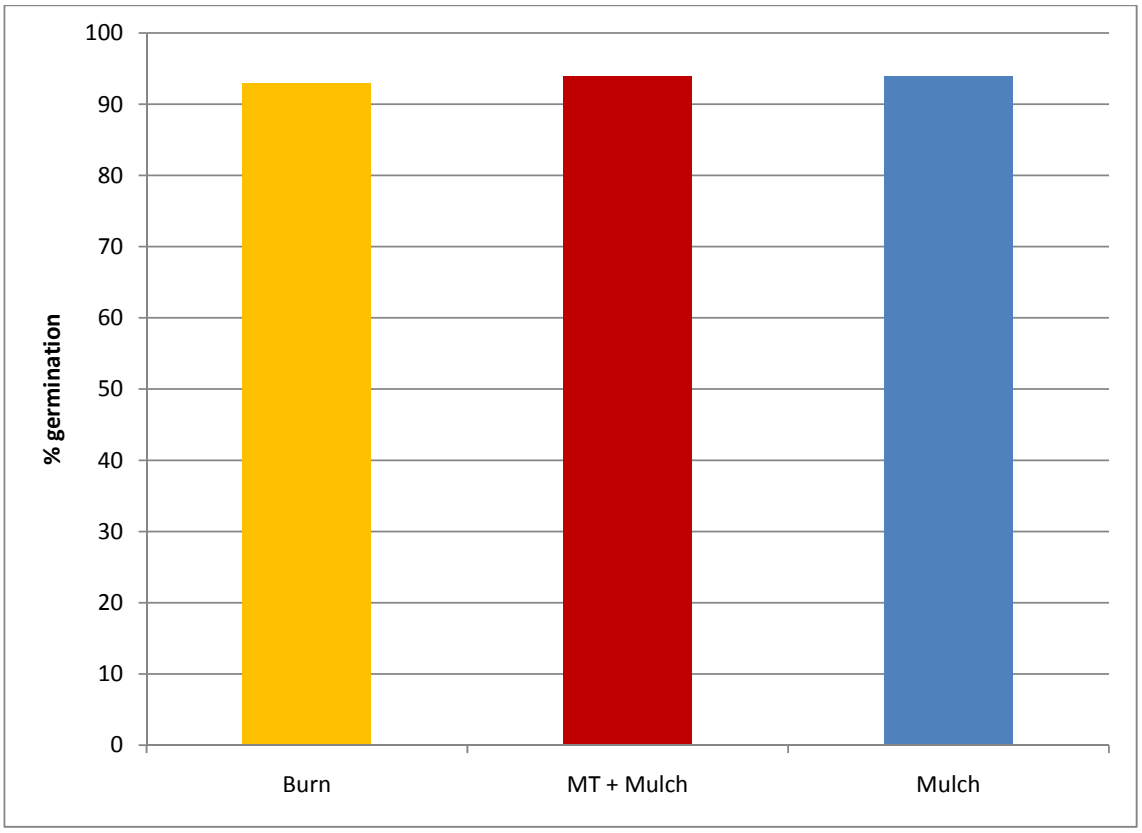
Table 4.5.1.3: Development of maize in Na Ot

Development stage	**Burn**		**Mini-terraces + Mulch**		**Mulch**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	0	21/04/10	0	21/04/10	0	21/04/10
V3-4	18	09/05/10	20	11/05/10	20	11/05/10
V7	36	27/05/10	36	27/05/10	35	26/05/10
VT	61	21/06/10	58	18/06/10	58	18/06/10
R1	64	24/06/10	59	19/06/10	61	21/06/10
R3	86	16/07/10	89	19/07/10	89	19/07/10
R5	100	30/07/10	103	02/08/10	103	02/08/10
Harvest	116	15/08/10	116	15/08/10	116	15/08/10

4.5.1.3.1 Germination rate

Germination rate ranged from 93 to 94 %. Statistical analysis could not be done because germination rate data were not recorded per replication. (Fig. 4.5.1.2).

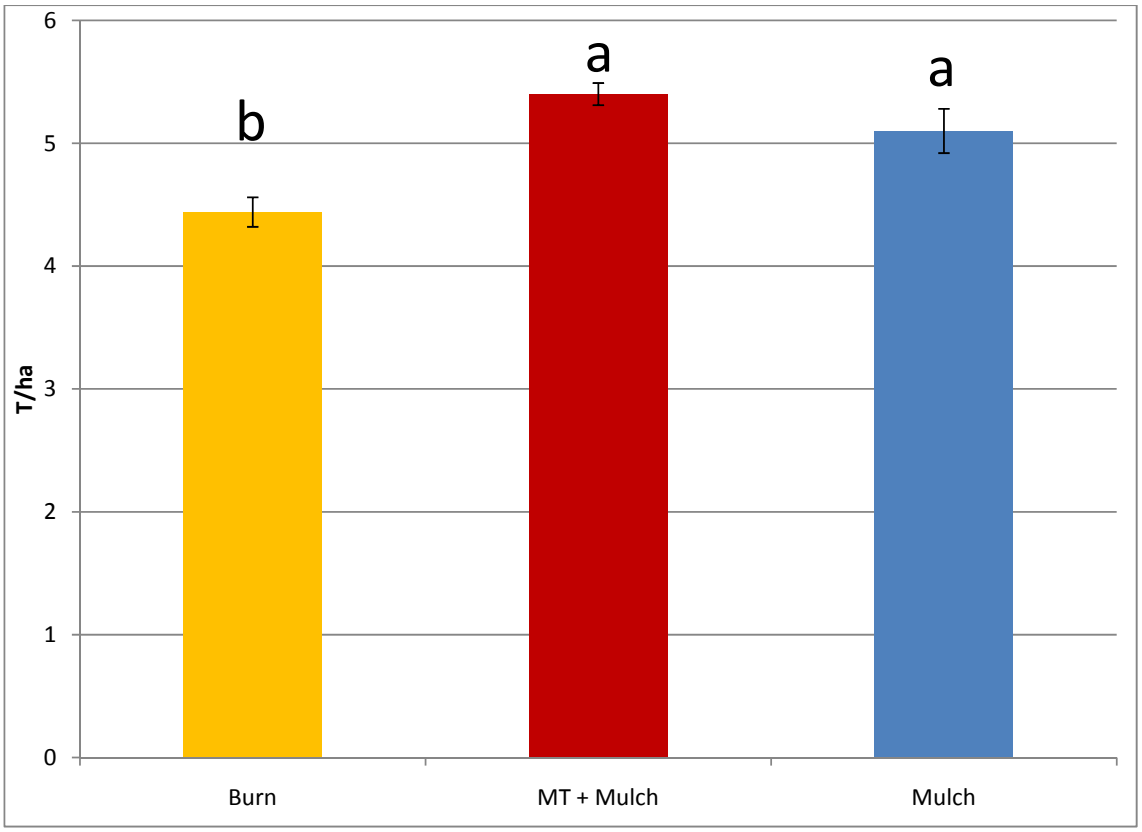
Figure 4.5.1.2: Germination rate of maize in different treatments



4.5.1.3.1 Yield

Yield ranged from 4.44 to 5.40 T/ha. There were significant differences in yield between treatments ($F_{2, 4}$ = 9.739, p=0.029). Yield of maize grown on mini terraces with mulch or where mulch was applied alone was significantly higher than yield of maize grown on soil where plant residues were burned before sowing ("burn"). There were no significant differences between yields on mini terraces with mulch or mulch alone. Results are presented in Figure 4.5.1.3.

Figure 4.5.1.3: Yield of maize in different treatments



Farmer practice was not part of the experimental design but yield on neighbouring fields of variety LVN10 was estimated at 3.5 T/ha. When compared with treatment "burn" in the experiment, yields in farmer fields was 22% lower.

4.5.1.3.4 Economic analysis

Basic economic analysis of the trial was conducted during participatory evaluation in September 2010. It compared existing farmer practice and experimental erosion management practices. Farmer researchers contributed to the estimation of work-days used for each production activity (Table 4.5.1.4) and estimation of input costs and income from maize sales.

Results shows that use of mini-terraces with mulch or use of mulch without mini-terraces in combination with high use of fertilisers increased production of maize by 53% and 44% respectively. However, high cost of inputs offset benefits of the higher production, so there were no significant differences in profit (excluding the labour cost) between farmer practice and the experimental treatment.

A much higher labour input was required to construct mini-terraces and bring mulch material into the field. (Table 4.5.1.4). Consequently when profit is expressed as profit relative to the labour input then value of a work-day was significantly lower for experimental treatments (112,230 and 107,984 VND per day of work for MT+mulch and mulch only respectively vs. 150,292 VND per day of work for farmer practice).

Table 4.5.1.4: Estimate of labour input

Operation	**Mini-Terraces + Mulch**	**Mulch**	**Farmer practice**
Slashing organic material	14	14	14
Ploughing	0	0	15
Ploughing to make row	12	6	4
Sowing + fertilising at sowing	21	21	21
Care (weeding)	10	10	10
Fertilizing	3	3	1.5
Mulching	10	10	0
Harvesting	30	30	20
Bringing mulch material from outside	30	30	0
Total	**130**	**124**	**85.5**

Table 4.5.1.5: Economic analysis of the experiment

	Unit	Cost (dong)	Amount			Value (dong)		
			Farmer	*MT+Mulch*	*Mulch*	*Farmer*	*MT+Mulch*	*Mulch*
Variety (LVN10)	**kg**	**38,000**	**17**	**0**	**0**	**646,000**		
Variety (LVN 99)	**kg**	**60,000**	**0**	**17**	**17**		**1,020,000**	**1,020,000**
Manure	**kg**	**350**	**100**	**0**	**0**	**35,000**		
Ure	**kg**	**6,800**	**50**	**300**	**300**	**340,000**	**2,040,000**	**2,040,000**
NPK (5:10:3)	**kg**	**3,300**	**100**	**0**	**0**	**330,000**		
Phosphate	**kg**	**3,100**	**0**	**500**	**500**		**1,550,00**	**1,550,000**
Kaliclorua	**kg**	**14,000**	**0**	**150**	**150**		**2,100,000**	**2,100,000**
Pestiside							**300,000**	**300,000**
Labour	**day**		**85.5**	**130**	**124**			
I-INPUT COST						**1,351,000**	**7,010,000**	**7,010,000**
II-INCOME	**kg**	**4,000**	**3,550**	**5,400**	**5,100**	**14,200,000**	**21,600,000**	**20,400,000**
III-PROFIT	**dong**					**12,850,000**	**14,590,000**	**13,390,000**
IV PROFIT/ LABOUR DAY	**Dong/ day**					**150,292**	**112,230**	**107,984**

4.5.1.4 Conclusions and comments

Results reconfirm the conclusions from Sin Ho (4.2.1.4): use of mulch and mini-terraces result in increased yield, but not to the extent that economically justify increased labour inputs.

Once again it was demonstrated that application of very high amounts of fertiliser did not result in proportional increases of income to justify investment. If farmer practice is compared with the “burn” treatment, then investment of 5,211,000 VND in additional fertiliser gave an increase in return of 3,760,000 VND or loss on investment of 1,451,000 VND.

It can be concluded that increase of only one production factor, in this case fertilisers, does not result in increased income if the whole cultivation system is not changed.

4.5.2 Experiment 2: Evaluation of mini-terraces and mulch as soil conservation practices for erosion reduction

4.5.2.1 Experimental objectives

The objective of the experiment was:

1. Evaluation of impacts of different soil management practices for erosion reduction on maize production.

4.5.2.2 Material and methods

4.5.2.2.1 Experimental design

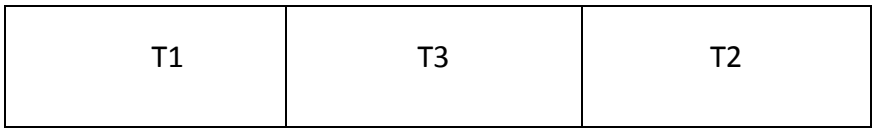
The experiment had 3 treatments and only 3 plots, one for each treatment. Since treatments were not replicated for all assessments 3 samples were randomly taken from 3 different locations within the plots and each sample was used as pseudo-replicate in statistical analysis.

Treatments were:

1. Burn (T1)
2. Mini-terraces + Mulch (T2)
3. Mulch (T3)

Each plot had an area of approximately 330 m^2 making a total experimental area of approximately 1000 m^2 (Fig. 4.5.2.1).

Fig 4.5.2.1: Schematic map of the experiment



4.5.2.2.2 Main cultivation activities

1. Sowing (18/04/2010). The maize variety LVN99 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Mulch was applied a few days after sowing using a variety of plant materials brought from nearby uncultivated land.
4. First fertiliser dressing was applied on 28/04/10
5. First weeding was done on 28/04/10
6. Second fertiliser dressing was applied on 31/05/10
7. Second weeding was done on 31/05/10
8. Third fertiliser dressing was applied on 10/06/10
9. Third weeding was done on 10/06/10

4.5.2.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.5.2.1).

Table 4.5.2.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
13/04/2010	Superphosphate (18%)	500	3,000	1,500,000
28/04/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
31/05/2010/V8-10	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
10/06/2010/V12-13	Urea (46% N)	120	6,800	816,000
	Kaliclorua (52% K)	60	14,000	840,000
			Total cost	**5,916,000**

4.5.2 Results

4.5.2.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.5.2.2 and Table 4.5.2.3 respectively.

Table 4.5.2.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN99	1.76 (0.09)	0.85 (0.01)	18.20 (0.24)	3.49 (0.05)	13.00 (0.09)	28.34 (0.54)	77	310

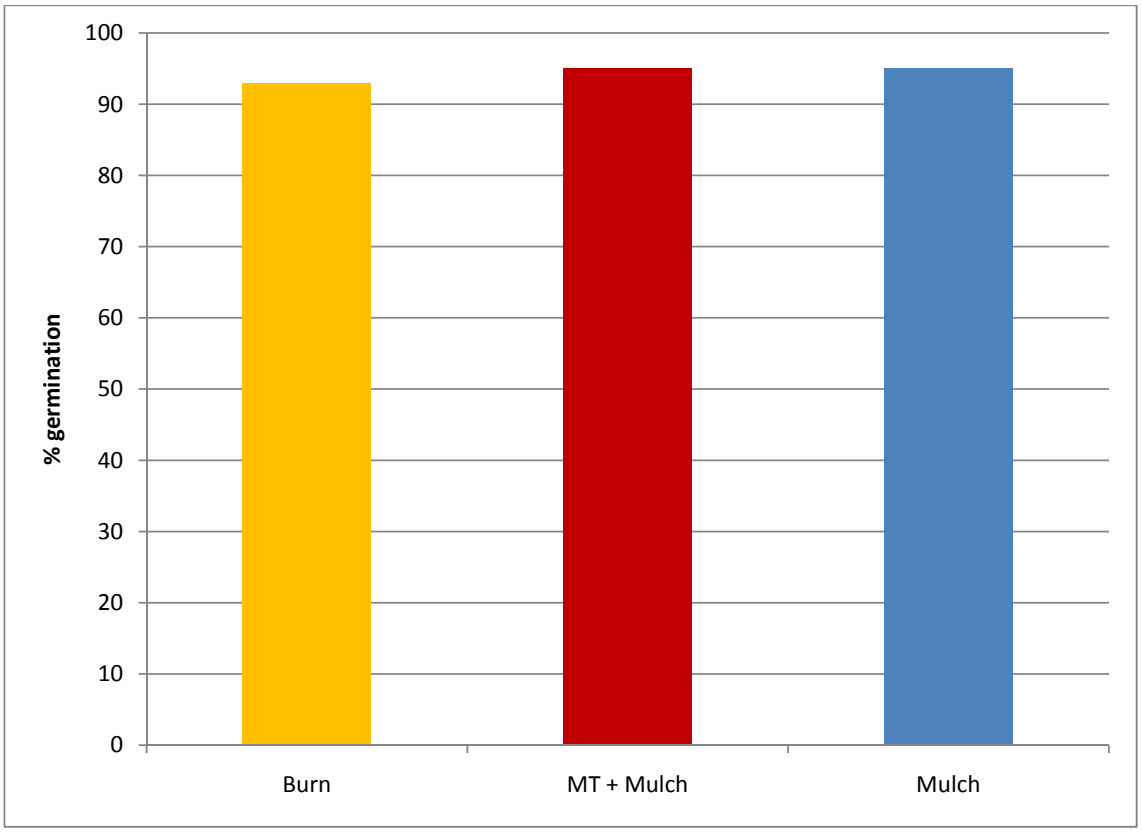
Table 4.5.2.3: Development of maize in Na Ot

Development stage	**Burn**		**Mini-terraces + Mulch**		**Mulch**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	0	21/04/10	0	21/04/10	0	21/04/10
V3-4	18	09/05/10	20	11/05/10	20	11/05/10
V7	36	27/05/10	36	27/05/10	35	26/05/10
VT	61	21/06/10	58	18/06/10	58	18/06/10
R1	64	24/06/10	59	19/06/10	61	21/06/10
R3	86	16/07/10	89	19/07/10	89	19/07/10
R5	100	30/07/10	103	02/08/10	103	02/08/10
Harvest	116	15/08/10	116	15/08/10	116	15/08/10

4.5.2.3.2 Germination rate

Germination rate ranged from 93 to 95 %. Statistical analysis could not be done because germination rate data were not recorded per replication. (Fig. 4.5.2.2).

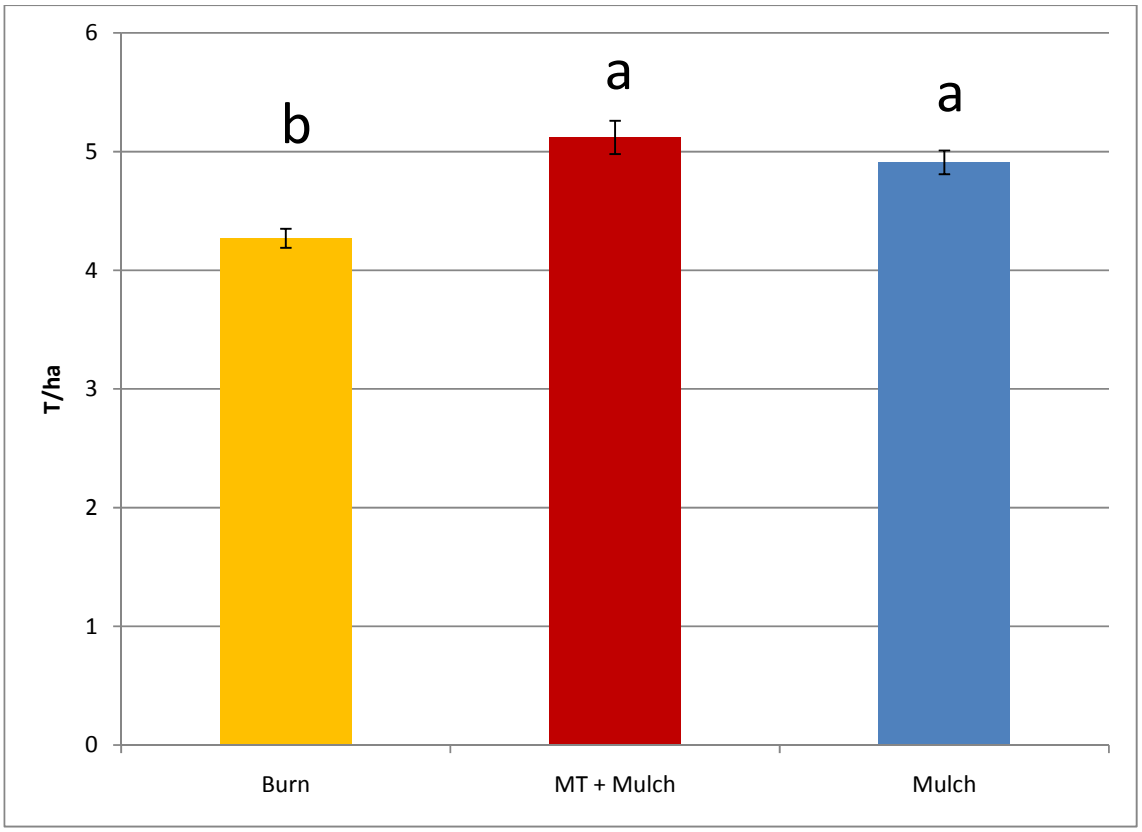
Figure 4.5.2.3: Germination rate of maize in different treatments



4.5.2.3.3 Yield

Yield ranged from 4.27 to 5.12 T/ha. There were significant differences in yield between treatments ($F_{2, 4}$ = 16.694, p=0.004). Yield of maize grown on mini terraces with mulch or where mulch was applied alone was significantly higher than yield of maize grown on soil where plant residues were burned before sowing ("burn"). There were no significant differences between yields on mini terraces with mulch or mulch alone. Results are presented in Figure 4.5.2.3.

Figure 4.5.2.3: Yield of maize in different treatments



4.5.2.4 Conclusions and comments

The findings from this experiment are consistent with the findings of the previous experiment (4.5.1) and they reconfirmed conclusions in 4.5.1.4.

4.6 Ta Chan Village – Chieng Chan Commune – Mai Son District – Son La Province

4.6.1 Experiment 1: Evaluation of new maize varieties

4.6.1.1 Experimental objectives

The objective of the experiment was to compare seven hybrid varieties of maize with the standard maize variety.

4.6.1.2 Material and methods

4.6.1.2.1 Experimental design

The experiment was designed as a randomized complete block with 8 treatments and 3 replicates.

Treatments were:

1. LVN 10 (Control) (T1)
2. LVN 14 (T2)
3. LVN 81 (T3)
4. LVN 154 (T4)
5. LCH 9 (T5)
6. LVN 146 (T6)
7. LVN 99 (T7)
8. LVN 61 (T8)

Each plot had an area of 250 m^2, with each block having an area of 2000 m^2 making a total experimental area of 6000 m^2 (Fig 4.6.1.1). Block 1 was assigned to Mr Khoi and blocks 2 and 3 were assigned to Mr Phan.

Fig 4.6.1.1: Schematic map of the experiment

Mr. Khoi

T8	T7	T6	T5	T4	T3	T2	T1

Mr. Phan

T1	T7	T4	T3	T5	T8	T2	T6
T3	T7	T5	T1	T6	T2	T8	T4

4.6.1.2.2 Main cultivation activities

1. Sowing (28-29/04/2010). All maize varieties were sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3).
2. Fertiliser was added at the time of sowing in same trenches as seeds but at a depth of 0.15 m
3. First fertiliser dressing was applied on 10/05/10
4. First weeding was done on 10/05/10
5. Second fertiliser dressing was applied on 27/05/10
6. Second weeding was done on 27/05/10
7. Third fertiliser dressing was applied on 06/06/10
8. Third weeding was done on 06/06/10

4.6.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.6.1.1).

Table 4.6.1.1: Time and amount of fertilisers applied

Date/ Development stage	**Fertiliser**	**Amount/ha (kg/ha)**	**Price/kg (VND)**	**Cost/ha (VND)**
Sowing 28/04/2010	Superphosphate (18%)	500	3,000	1,500,000
10/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
27/05/2010/V7-8	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
06/06/2010 V10-12	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	5,640,000

4.6.1.3 Results

4.6.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.6.1.2 and Table 4.6.1.3 respectively.

Table 4.6.1.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN 10	1.93 (0.01)	1.02 (0.02)	17.67 (0.28)	3.53 (0.06)	13,47 (0.13)	31.00 (0.5)	74	310
LVN 14	1.97 (0.01)	0.99 (0.02)	18.20 (0.50)	3.75 (0.02)	13.80 (0.35)	32.97 (0.76)	76	330
LVN 81	1.94 (0.02)	0.99 (0.02)	17.03 (0.15)	3.45 (0.07)	13.27 (0.52)	30.63 (1.50)	80	300
LVN 154	1.88 (0.02)	0.98 (0.01)	16.93 (0.38)	3.39 (0.04)	12.93 (0.37)	29.03 (0.67)	73	290
LCH 9	2.02 (0.02)	1.06 (0.01)	19.20 (0.15)	4.08 (0.08)	14.00 (0.20)	34.10 (0.31)	81	300
LVN 146	1.49 (0.01)	97.40 (0.01)	17.63 (0.09)	3.42 (0.04)	13.27 (0.18)	30.93 (0.35)	74	300
LVN 99	1.97 (0.03)	1.01 (0.03)	18.60 (0.06)	3.86 (0.07)	13.73 (0.24)	33.53 (0.41)	83	310
LVN 61	1.89 (0.01)	0.99 (0.02)	17.90 (0.12)	3.67 (0.06)	13.27 (0.07)	32.67 (0.78)	80	320

All tested varieties have very similar morphological characteristics. The only noticeable difference is the short height of variety LVN 146 (0.5 m shorter than control LVN10). New varieties have 10-14 days shorter development time which can be a significant advantage for planting the second crop on time.

Table 4.6.1.3: Development of maize in Chieng Chan

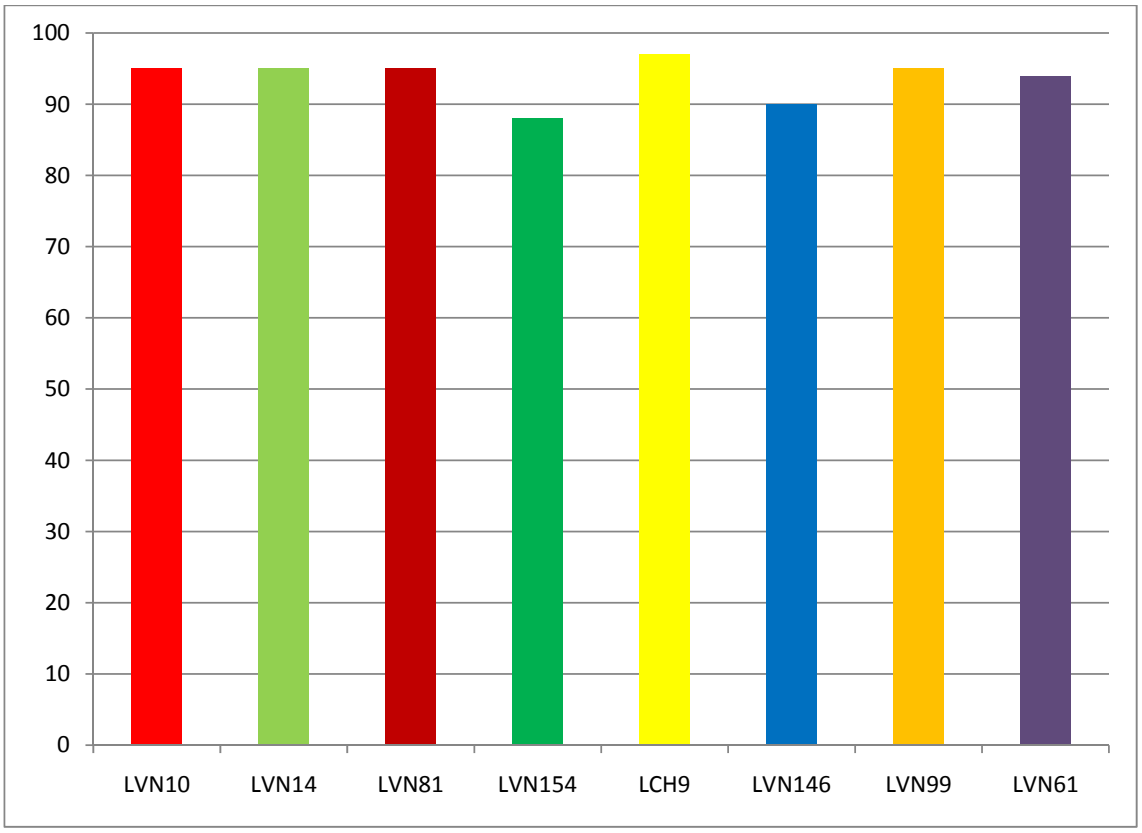
Development stage	LVN10 (Đ/c)		LVN14		LVN81		LVN154		LCH9		LVN146		LVN99		LVN61	
	DAS	Date	DAS	Date	DAS	Date	DAS	Date	DAS	Date	DAS	Date	DAS	Date	DAS	Date
Sowing	0	28/04/10	0	28/04/10	0	28/04/10	0	28/04/10	0	28/04/10	0	28/04/10	0	28/04/10	0	28/04/10
V3-4	21	19/05/10	21	19/05/10	18	16/05/10	19	17/05/10	20	18/05/10	22	20/05/10	18	16/05/10	19	17/05/10
V7	37	04/06/10	38	05/06/10	39	06/06/10	40	07/06/10	38	05/06/10	40	07/06/10	37	04/06/10	48	15/06/10
VT	63	30/06/20	62	29/06/10	62	29/06/10	58	25/06/10	58	25/06/10	54	21/06/10	58	25/06/10	60	27/06/10
R1	65	02/07/10	64	01/07/10	64	01/07/10	61	28/06/10	62	29/06/10	57	24/06/10	61	28/06/10	64	01/07/10
R3	90	27/07/10	78	15/07/10	80	17/07/10	77	14/07/10	72	09/07/10	73	10/07/10	72	09/07/10	76	13/07/10
R5	94	31/07/10	82	19/07/10	84	21/07/10	82	19/07/10	79	16/07/10	78	15/07/10	78	15/07/10	82	19/07/10
Harvest	106	12/08/10	96	02/08/10	96	02/08/10	94	31/07/10	94	31/07/10	91	28/07/10	92	29/07/10	96	02/08/10

[1]DAS=Days after sowing

4.6.1.3.2 Germination rate

Germination rate ranged from 88 to 97 % (Fig 4.6.1.2). Data were not recorded per replicates so statistical analysis was not possible.

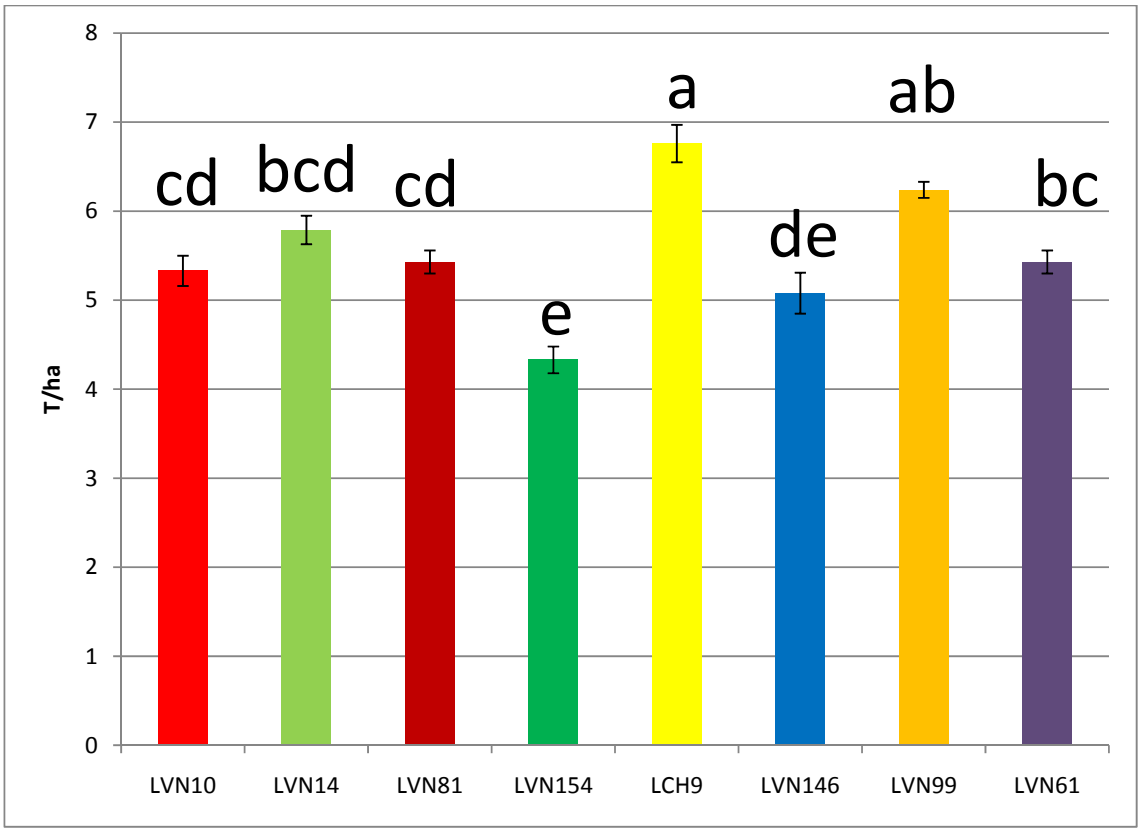
Figure 4.6.1.2: Germination rate of maize in different treatments



4.6.1.3.3 Yield

Yield ranged between 4.33 and 6.76 T/ha. There were significant differences in yield between treatments ($F_{7, 14}$ = 14.775, p<0.001). Maize variety LCH 9 had statistically significantly higher yield than any other variety except for variety LVN99. Variety LVN99 had significantly higher yield than varieties LVN 10, LVN 146, LVN 154 and LVN 81. Variety LVN 61 had significantly higher yield than varieties LVN 156 and LVN 154. Varieties LVN 10, LVN14 and LVN 81 had significantly higher yield than Variety LVN 154. There were no significant differences between other varieties. Results are presented in Figure 4.6.1.3

Figure 4.6.1.3: Yield of maize in different treatments



4.6.1.4 Conclusions and comments

Varieties LCH9, LVN99 and LVN61 had significantly higher yields than the control. Variety LCH9 is drought tolerant and had the highest yield which would make it a good candidate for testing as a second crop in 2011.

4.6.2 Experiment 2: Influence of intercropping with rice beans on maize productivity

4.6.2.1 Experimental objectives

The objective of the experiment was to evaluate the influence of intercropping with rice beans on maize productivity

4.6.2.2 Materials and methods

4.6.2.2.1 Experimental design

The experiment was a randomised complete block design with 2 treatments and 3 replicates.

Treatments were:

1. Maize (T1)
2. Maize intercropped with rice beans (T2)

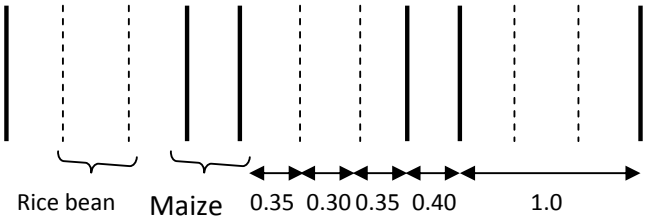
Each plot had an area of 200 m^2, with each block having an area of 400 m^2 making a total experimental area of approximately 1200 m^2 (Fig 4.6.2.1).

Fig 4.6.2.1: Schematic map of the experiment

T2	T1	T2	T1	T2	T1

4.6.2.2.2 Main cultivation activities

1. Sowing (27/04/2010). Maize (LVN99) was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. In treatment T2 (intercropping) maize was sown in strips of two rows of maize with a narrow spacing of 0.4 m. Spacing between 2 strips was 1 m. rice bean was sown in two rows 0.3 m apart into the 1m-space between two maize strips (see diagram below).



3. Fertiliser was added only to maize at the time of sowing in same trenches as seeds but at a depth of 0.15 m
4. First fertiliser dressing was applied on 10/05/10
5. First weeding was done on 10/05/10
6. Second fertiliser dressing was applied on 27/05/10
7. Second weeding was done on 27/05/10
8. Third fertiliser dressing was applied on 06/06/10
9. Third weeding was done on 06/06/10

4.6.2.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.6.2.1).

Table 4.6.2.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
Sowing 27/04/2010	Superphosphate (18%)	500	3,000	1,500,000
10/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
27/05/2010/V7-8	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
06/06/2010/V12-13	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	5,640,000

4.6.2.3 Results

4.6.2.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.6.2.2 and Table 4.6.2.3 respectively.

Table 4.6.2.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN61	1.85 (0.01)	0.83 (0.01)	18.88 (0.20)	3.52 (0.04)	13.93 (0.13)	33.93 (0.85)	78	320

Table 4.6.2.3: Development of maize in Chieng Chan

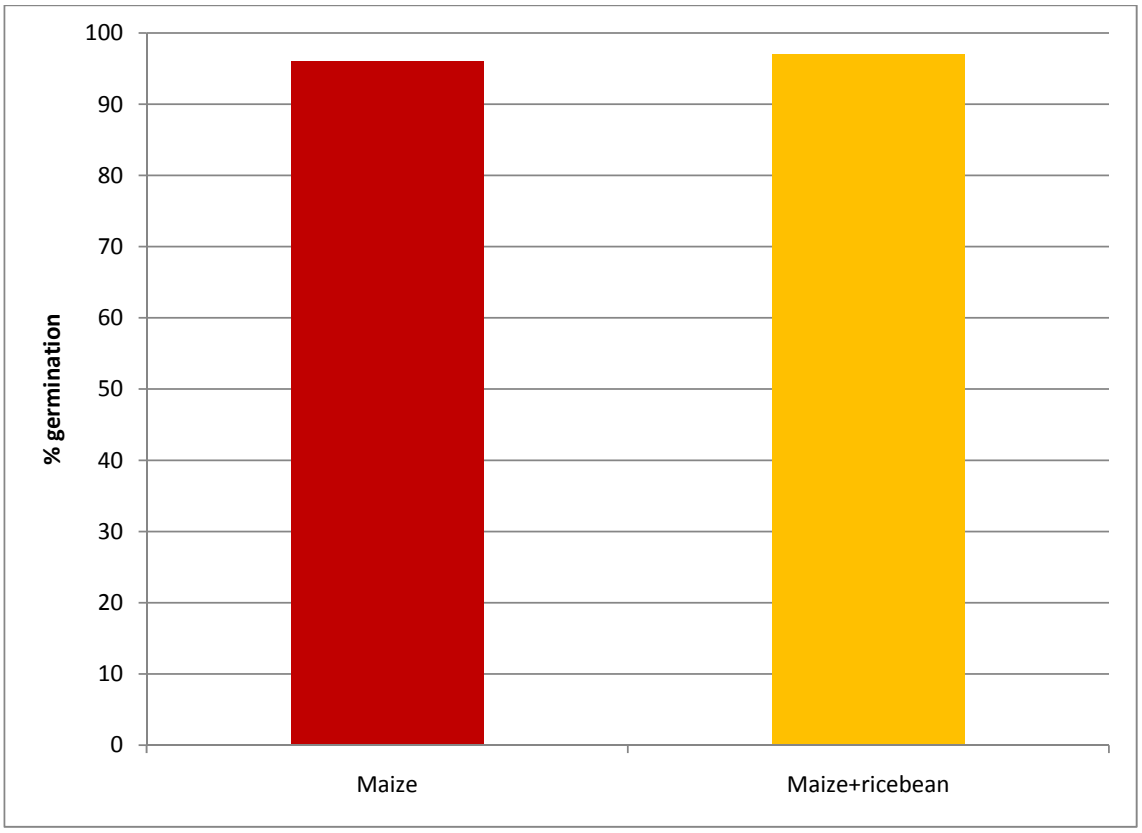
Development stage	**Maize**		**Maize + rice bean**	
	DAT	**Date**	**DAT**	**Date**
Sowing	0	27/04/10	0	27/04/10
V3-4	18	15/05/10	17	14/05/10
V7	37	03/06/10	37	03/06/10
VT	61	27/06/10	61	27/06/10
R1	63	29/06/10	63	29/06/10
R3	75	11/07/10	76	12/07/10
R5	88	24/07/10	89	25/07/10
Harvest	98	03/08/10	100	05/08/10

[1]DAS=Days after sowing

4.6.2.3.2 Germination rate

Germination rate ranged from 96 to 97 % (Fig. 4.6.2.2). Data were not recorded per replicates so statistical analysis was not possible.

Figure 4.6.2.2: Germination rate of maize in different treatments



4.6.2.3.3 Yield

Yield ranged between 5.49 and 6.50 T/ha. There were significant differences in yield between treatments ($F_{1, 2}$ = 20.017, p=0.047) (Fig. 4.6.2.3). Yield of maize was higher when intercropped with rice bean than when planted as a monocrop.

Figure 4.6.2.3: Yield of maize in different treatments

4.6.2.4 Conclusions and comments

Results are consistent with results from experiment 4.4.2. Intercropping with ricebean had a positive effect on maize growth and resulted in higher yield. However, just higher yield of maize is unlikely to justify investment of money and time in growing an intercrop if no income can be derived from the intercrop itself. Crop management strategies need to be developed in the 2011 experiment to achieve a reasonable yield from the legume crop.

4.7 La Nga Village – Muong Sang Commune – Moc Chau District

4.7.1 Experiment 1: Evaluation of mini-terraces and mulch as soil conservation practices for erosion reduction

4.7.1.1Experimental objectives

Objectives of the experiment have been:

1. Evaluation of longer term (3 years) effectiveness of different soil management practices for erosion reduction.

2. Evaluation of impacts of different soil management practices for erosion reduction on maize production.

4.7.1.2 Material and methods

4.7.1.2.1 Experimental design

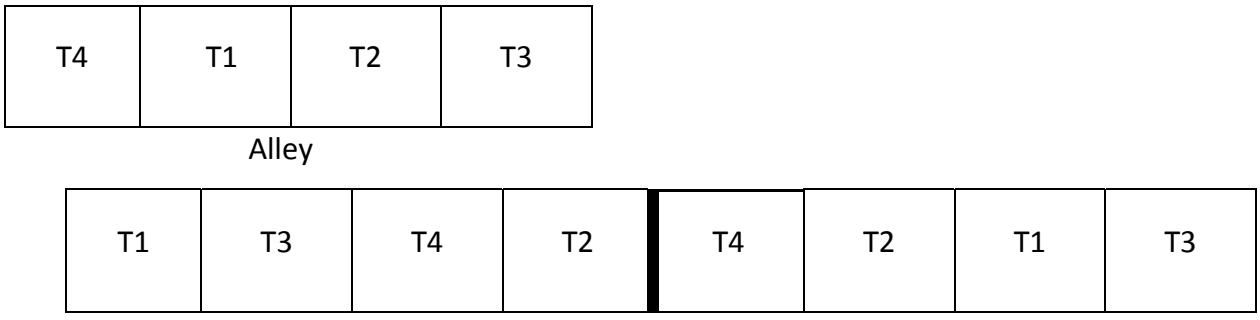
The experiment was designed as a randomized complete block with 4 treatments and 3 replicates.

Treatments were:

1. Burn (T1)
2. Mini-terraces + Mulch (T2)
3. Pinto peanut (T3)(not implemented; effectively equal to T1)
4. Mulch (T4)

Each plot had an area of approximately 200 m^2, with each block having approximately 800 m^2 making a total experimental area of approximately 2400 m^2 (Fig. 4.7.1.1).

Fig 4.7.1.1: Schematic map of the experiment



4.7.1.2.2Main cultivation activities

1. Sowing (13/05/2010). The maize variety LVN61 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Mulch was applied a few days after sowing using a variety of plant materials brought from nearby uncultivated land.
4. First fertiliser dressing was applied on 24/05/10
5. First weeding was done on 24/05/10
6. Second fertiliser dressing was applied on 13/06/10
7. Second weeding was done on 13/06/10
8. Third fertiliser dressing was applied on 30/06/10
9. Third weeding was done on 30/06/10

4.7.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.7.1.1).

Table 4.7.1.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
13/05/2010	Superphosphate (18%)	500	3,000	1,500,000
24/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
13/06/2010/V7-8	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
30/06/2010/V12-13	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	**5,640,000**

4.7.1.3 Results

4.7.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.7.1.2 and Table 4.7.1.3 respectively.

Table 4.7.1.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN61	2.13 (0.05)	1.08 (0.02)	14.44 (0.17)	4.58 (0.03)	14.49 (0.10)	33.41 (0.83)	79	299

Table 4.7.1.3: Development of maize in Muong Sang

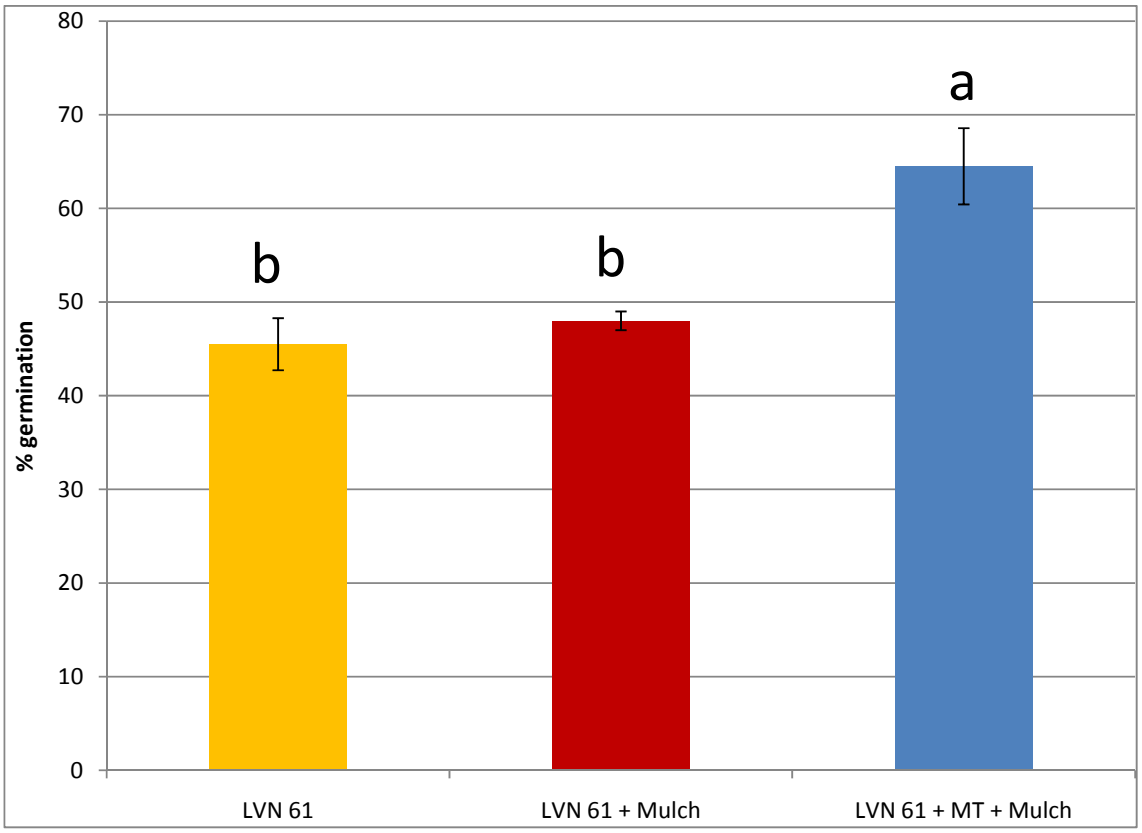
Development stage	**LVN 61**		**LVN 61 +MT+M**		**LVN 61 + M**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	0	13/05/10	0	13/05/10	0	13/05/10
V3-4	13	26/05/10	12	25/05/10	13	26/05/10
V7	44	26/06/10	42	24/06/10	43	25/06/10
VT	59	11/07/10	60	12/07/10	60	12/07/10
R1	69	21/07/10	69	21/07/10	69	21/07/10
R3	84	05/08/10	82	03/08/10	83	04/08/10
R5	97	18/08/10	94	15/08/10	95	16/08/10
Harvest	104	25/08/10	101	22/08/10	103	24/08/10

The development time for variety LVN61 in Moc Chau seems to be up to 10 days longer than in Mai Son which could be attributed to cooler weather in Moc Chau.

4.7.1.3.2 Germination rate

Germination rate ranged from 46 to 66 %. There were significant differences between treatments in germination rate ($F_{2, 4}$ = 34.26, p=0.003) (Fig. 4.7.1.2). The germination rate was significantly higher where maize was sown on mini-terraces and mulch was added. There were no significant differences between other treatments.

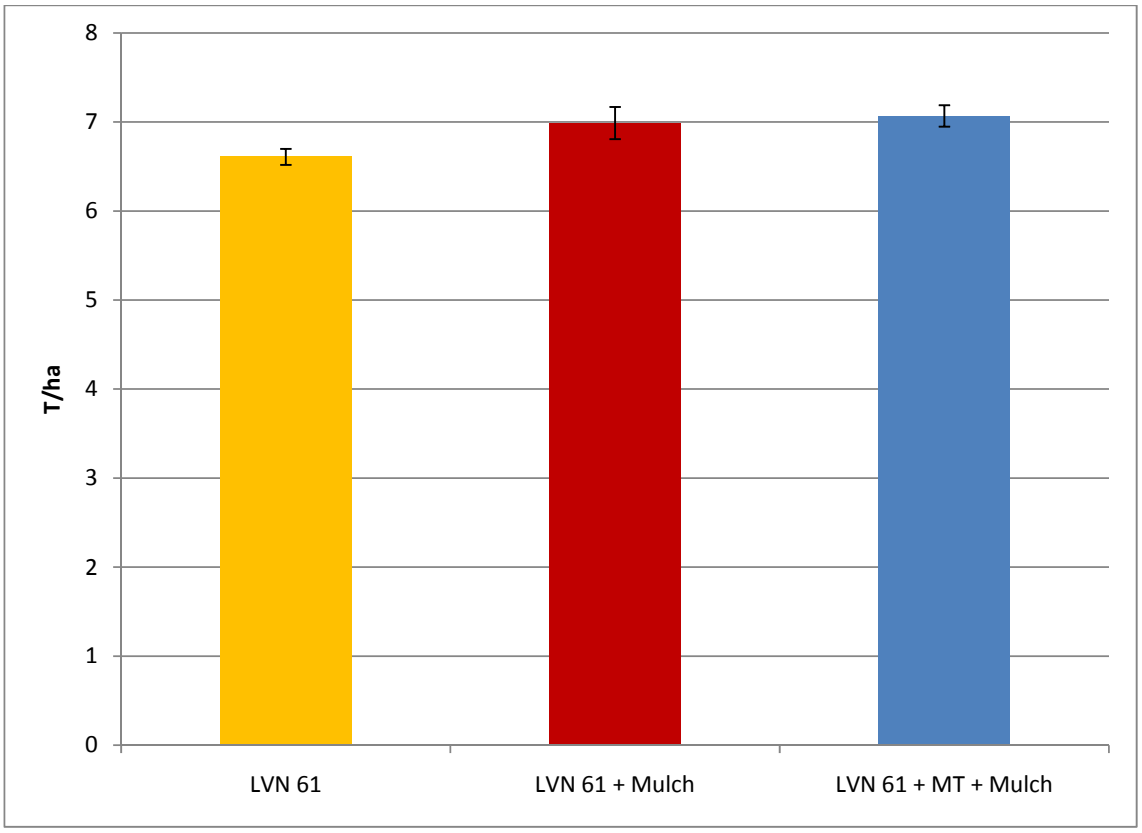
Figure 4.7.1.2: Germination rate of maize in different treatments



4.7.1.3.3 Yield

Yield ranged from 6.60 to 7.07 T/ha. There were no significant differences in yield between treatments ($F_{2, 4}$ = 2.938, p=0.164). Results are presented in Figure 4.7.1.3.

Figure 4.7.1.3: Yield of maize in different treatments



4.7.1.4 Conclusions and comments

Yield in all treatments was relatively high and use of mulch did not significantly increase yield. Maize was sown too late in this experiment and Pinto peanut did not establish. Erosion measurement taken at this site clearly demonstrated that mini-terraces with mulch significantly reduced erosion.

The farmer sold their land after the maize was harvested and the experiment at this location will be discontinued.

4.7.2 Experiment 2: Evaluation of mini-terraces and mulch as soil conservation practices for erosion reduction

4.7.2.1 Experimental objectives

The objective of the experiment was:

1. Evaluation of impacts of different soil management practices for erosion reduction on maize production.

4.7.2.2 Material and methods

4.7.2.2.1 Experimental design

The experiment was designed as a randomized complete block with 4 treatments and 3 replicates.

Treatments were:

1. Burn (T1)
2. Mini-terraces + Mulch (T2)
3. Pinto peanut (T3)(not implemented; effectively equal to T1)
4. Mulch (T4)

Each plot had an area of approximately 200 m^2, with each block having approximately 800 m^2 making a total experimental area of approximately 2400 m^2 (Fig. 4.7.2.1).

Fig 4.7.2.1: Schematic map of the experiment

T1	T2	T3	T4
T3	T4	T1	T2
T2	T1	T4	T3

4.7.2.2.2 Main cultivation activities

1. Sowing (13/05/2010). The maize variety LVN99 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Mulch was applied a few days after sowing using a variety of plant materials brought from nearby uncultivated land.

4. First fertiliser dressing was applied on 24/05/10
5. First weeding was done on 24/05/10
6. Second fertiliser dressing was applied on 13/06/10
7. Second weeding was done on 13/06/10
8. Third fertiliser dressing was applied on 30/06/10
9. Third weeding was done on 30/06/10

4.7.2.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.7.2.1).

Table 4.7.2.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
13/05/2010	Superphosphate (18%)	500	3,000	1,500,000
24/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
13/06/2010/V7-8	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
30/06/2010/V12-13	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	**5,640,000**

4.7.2.3 Results

4.7.2.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.7.2.2 and Table 4.7.2.3 respectively.

Table 4.7.2.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN61	2.13 (0.05)	1.08 (0.02)	14.44 (0.17)	4.58 (0.03)	14.49 (0.10)	33.41 (0.83)	76	298

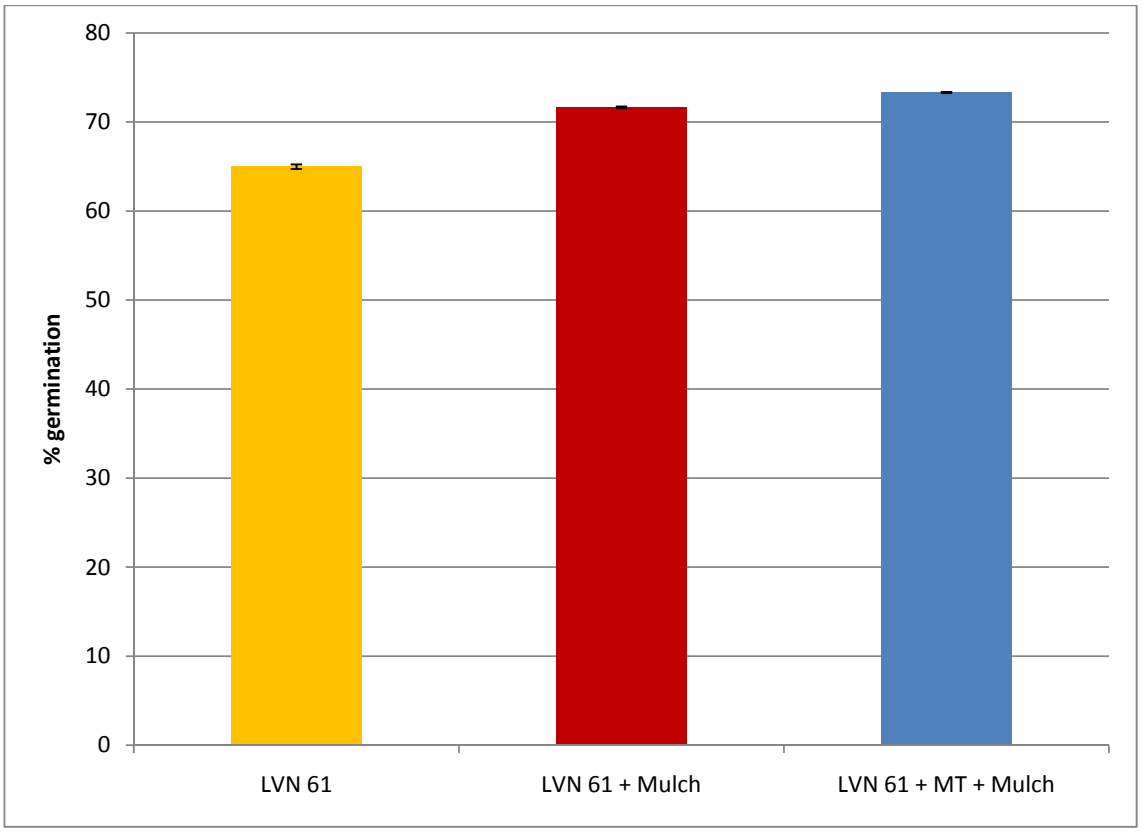
Table 4.7.2.3: Development of maize in Muong Sang

Development stage	LVN 61		LVN 61 +MT+M		LVN 61 + M	
	DAS	Date	DAS	Date	DAS	Date
Sowing	0	13/05/10	0	13/05/10	0	13/05/10
V3-4	13	26/05/10	12	25/05/10	13	26/05/10
V7	43	25/06/10	44	26/06/10	43	25/06/10
VT	62	14/07/10	62	14/07/10	61	13/07/10
R1	74	26/07/10	74	26/07/10	73	25/07/10
R3	83	04/08/10	82	03/08/10	82	03/08/10
R5	97	18/08/10	95	16/08/10	96	17/08/10
Harvest	106	27/08/10	105	26/08/10	105	26/08/10

4.7.2.3.2 Germination rate

Germination rate ranged from 65 to 73 %. There were no statistically significances between treatments ($F_{2, 6} = 4.20$, p=0.072) (Fig. 4.7.2.2).

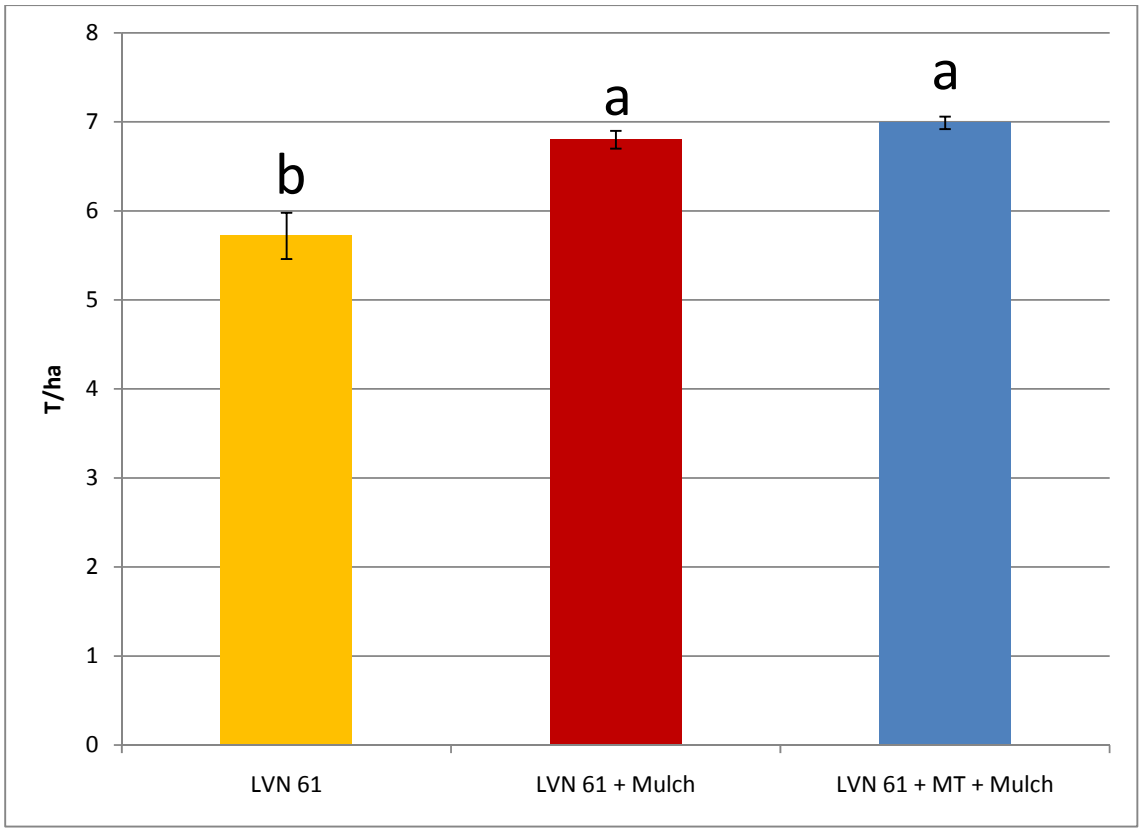
Figure 4.7.2.2: Germination rate of maize in different treatments



4.7.2.3.3 Yield

Yield ranged from 5.72 to 6.99 T/ha. There were significant differences in yield between treatments ($F_{2, 6}$ = 17.230, p=0.003). Yield of maize grown on mini terraces with mulch or where mulch was applied alone was significantly higher than yield of maize grown on soil where plant residues were burned before sowing ("burn"). There were no significant differences between yields on mini terraces with mulch or mulch alone. Results are presented in Figure 4.7.2.3.

Figure 4.7.2.3: Yield of maize in different treatments



4.7.2.4 Conclusions and comments

Mulch and mini-terraces provided very good protection from erosion and at the same time yield was significantly increased. However it seems that farmer's awareness of long term erosion damage and their willingness to protect their fields is necessary for implementation of mini-terraces with mulch since yield increase of 1.2 T/ha alone is not enough to justify higher labour input.

4.7.3 Experiment 3: Influence of intercropping with peanuts and rice beans on maize productivity

4.7.3.1 Experimental objectives

The objective of the experiment was:

1. Evaluate the influence of intercropping with peanuts and rice beans on maize productivity

4.7.3.2 Materials and methods

4.7.3.2.1 Experimental design

The experiment was a randomised complete block design with 4 treatments and 3 replicates.

Treatments were:

1. Maize mono-crop (T1)
2. Maize intercropped with pinto peanut (T2) (pinto peanut did not establish effectively and this treatment was disregarded in the analysis)
3. Maize intercropped with peanut (T3)
4. Maize intercropped with rice bean (T4)

Each plot had an area of 100 m^2, with each block having an area of 400 m^2 making a total experimental area of approximately 1200 m^2 (Fig. 4.7.3.1).

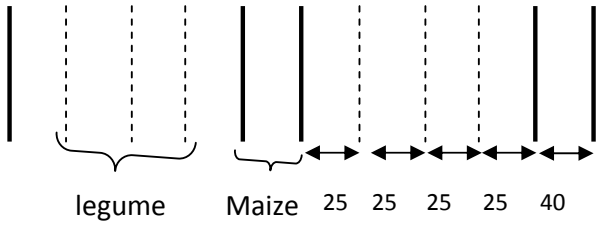
Fig. 4.7.3.1: Schematic map of the experiment

T2	T3	T4	T1
T4	T1	T3	T2
T1	T4	T2	T3

4.7.3.2.2 Main cultivation activities

1. Sowing (08/05/2010). Maize hybrid NK66 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3). Rice bean was sown together with maize. Peanut (unknown local variety) was sown at a depth of 0.05 m.

2. In treatment T2 (intercropping) maize was sown in strips of two rows of maize with a narrow spacing of 0.4 m. Spacing between 2 strips was 1 m. Legumes were sown in three rows 0.25 m apart into the 1m-space between two maize strips (see diagram below).



Fertiliser was added only to maize at the time of sowing in same trenches as seeds but at a depth of 0.15 m

3. First fertiliser dressing was applied on 15/05/10
4. First weeding was done on 15/05/10
5. Second fertiliser dressing was applied on 03/06/10
6. Second weeding was done on 03 /06/10
7. Third weeding and soil cultivation was done when plants developed 13-14 leaves
8. Third fertiliser dressing was applied on 26/06/10
9. Third weeding was done on 26/06/10

4.7.3.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.7.3.1).

Table 4.7.3.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
08/05/2010	Superphosphate (18%)	500	3,000	1,500,000
15/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
03/06/2010/V8-10	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
26/06/2010/V12-13	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	**5,640,000**

4.7.3.3 Results

4.7.3.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.7.3.2 and Table 4.7.3.3 respectively.

Table 4.7.3.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
NK66	2.31 (0.02)	1.17 (0.01)	17.67 (0.37)	3.40 (0.03)	15.36 (0.10)	30.82 (0.38)	79	299,67

Table 4.7.3.3: Development of maize in Muong Sang

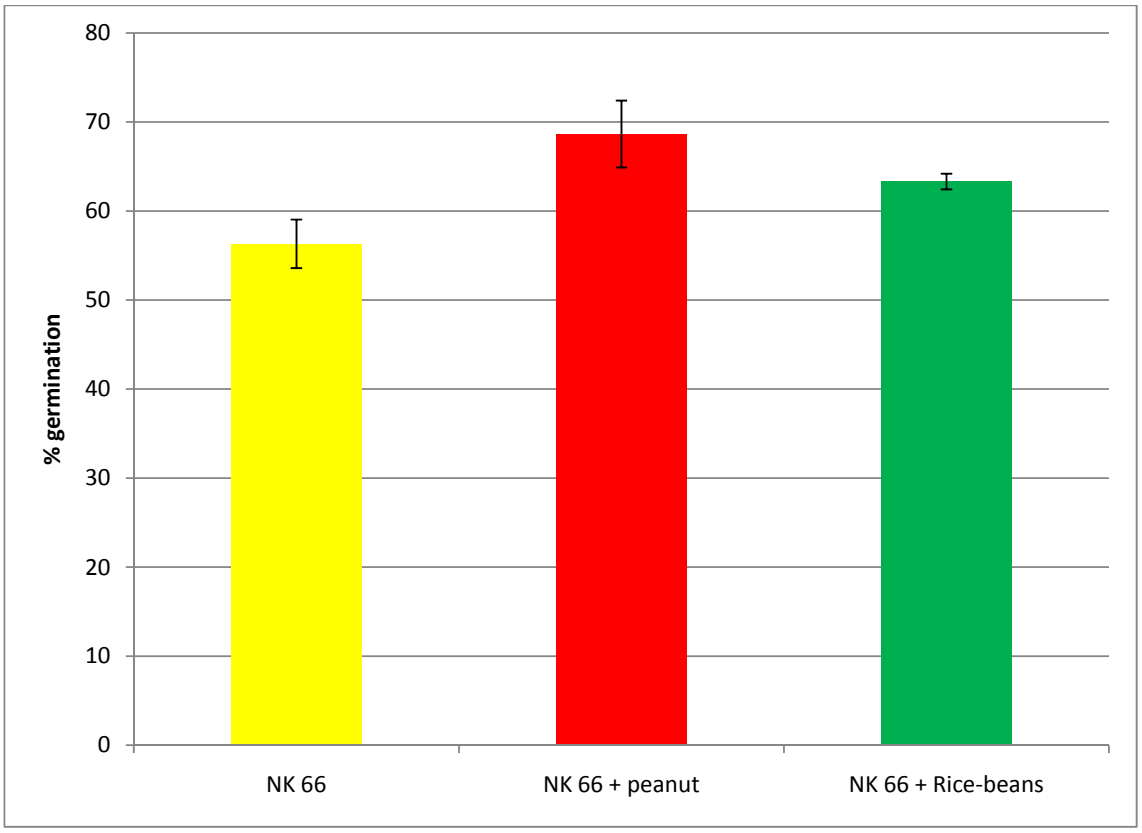
Development stage	**NK66**		**NK66 + Peanut**		**NK66 + Rice-bean**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	0	08/05/10	0	08/05/10	0	08/05/10
V3-4	13	21/05/10	13	21/05/10	12	20/05/10
V10	43	20/06/10	43	20/06/10	44	21/06/10
VT	64	11/07/10	64	11/07/10	62	09/07/10
R1	75	22/07/10	75	22/07/10	75	22/07/10
R3	84	31/07/10	84	31/07/10	84	31/07/10
R5	97	13/08/10	95	11/08/10	95	11/08/10
Harvest	106	22/08/10	105	21/08/10	105	21/08/10

[1]DAS=Days after sowing

4.7.3.3.2 Germination rate

Germination rate ranged from 56 to 69 %. There were no significant differences between treatments in germination rate ($F_{2,4}$ = 6.337, p=0.058) (Fig. 4.7.3.2).

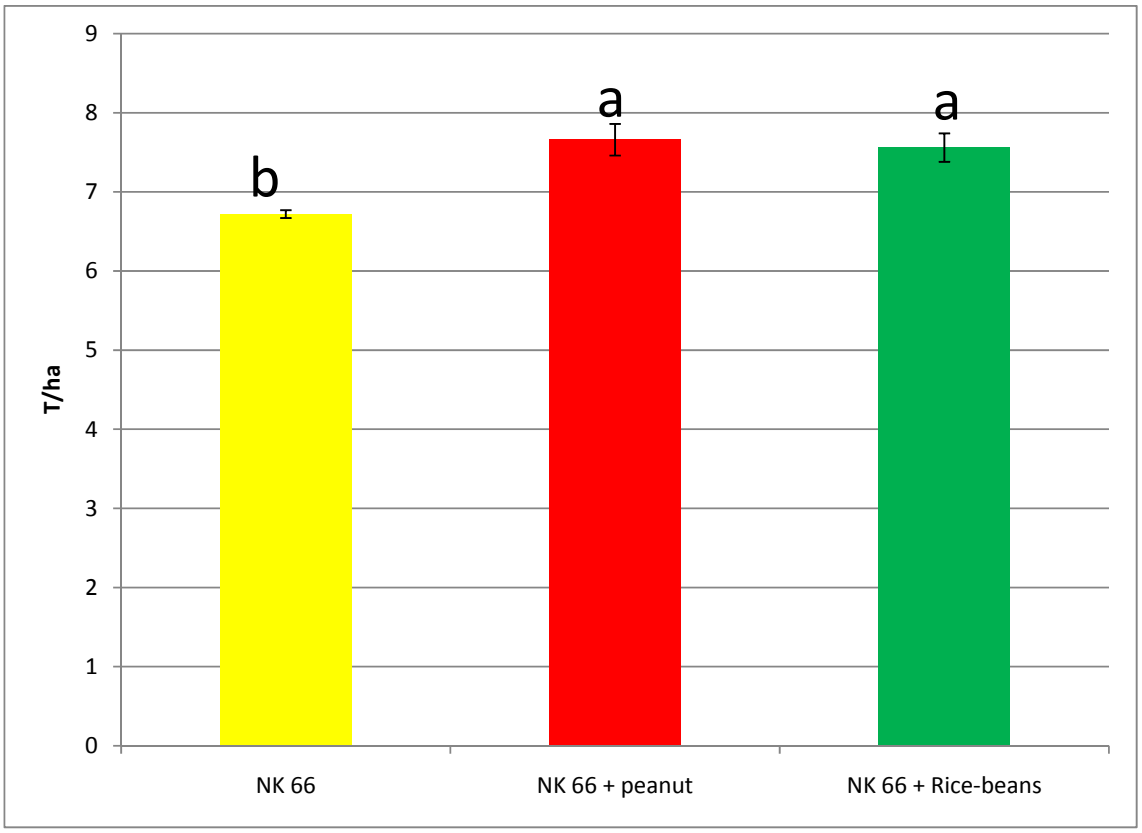
Figure 4.7.3.2: Germination rate of maize in different treatments



4.7.3.3.3 Yield

Yield ranged between 6.72 and 7.66 T/ha. There were significant differences in yield between treatments ($F_{2,4}$ = 7.246, p=0.047) (Fig. 4.7.3.3). Yield of maize was significantly higher when intercropped with peanut and rice bean than when planted as a monocrop. There was no significant difference between the yield of maize when intercropped with peanut or rice bean.

Figure 4.7.3.3: Yield of maize in different treatments



4.7.3.4 Conclusions and comments

Results of this experiment are consistent with other experiments (4.4.1, 4.4.2 and 4.6.2): intercropping with legumes had a positive effect on maize growth and results in higher yield. While in previous experiments black beans and rice beans were used but there was no successful harvest, in this experiment a small crop (about 1T/ha) of peanuts was harvested.

4.8 Pieng Sang Village – Phieng Luong Commune – Moc Chau District

4.8.1 Experiment 1: Impact of mulch on maize production

4.8.1.1 Experimental objectives

The objective of the experiment was to assess impact of mulch on maize production.

4.8.1.2 Materials and methods

4.8.1.2.1 Experimental design

The experiment was a randomised complete block design with 2 treatments and 3 replicates.

Treatments were:

1. Maize sown on bare soil (T1)
2. Maize sown with mulch (T2)

Each plot had an area of approximately 200 m^2 with each block having an area of 400 m^2 making a total experimental area of approximately 1200 m^2 (Fig. 4.8.1.1).

Fig 4.8.1.1: Schematic map of the experiment

T2	T1
T1	T2
T2	T1

4.8.1.2.2 Main cultivation activities

1. Sowing (14/04/2010). Maize variety NK66 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. Stubble from previous season was used as mulch.
4. First fertiliser dressing was applied on 28/04/10
5. First weeding was done on 28/04/10

6. Second fertiliser dressing was applied on 14/05/10
7. Second weeding was done on 14/05/10
8. Third fertiliser dressing was applied on 28/05/10
9. Third weeding was done on 28/05/10

4.8.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.8.1.1).

Table 4.8.1.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
14/04/2010 Sowing	Superphosphate (18%)	500	3,000	1,500,000
28/04/2010/V4-5	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
14/05/2010/V8-10	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
28/05/2010/V12-13	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	**5,640,000**

4.8.1.3 Results

4.8.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.8.1.2 and Table 4.8.1.3 respectively.

Table 4.8.1.2: Maize characteristics

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
NK66	2.64 (0.03)	1.18 (0.03)	17.18 (0.21)	5.14 (0.05)	15.17 (0.10)	34.88 (0.69)	80	303

Table 4.8.1.3: Development of maize in Phieng Luong

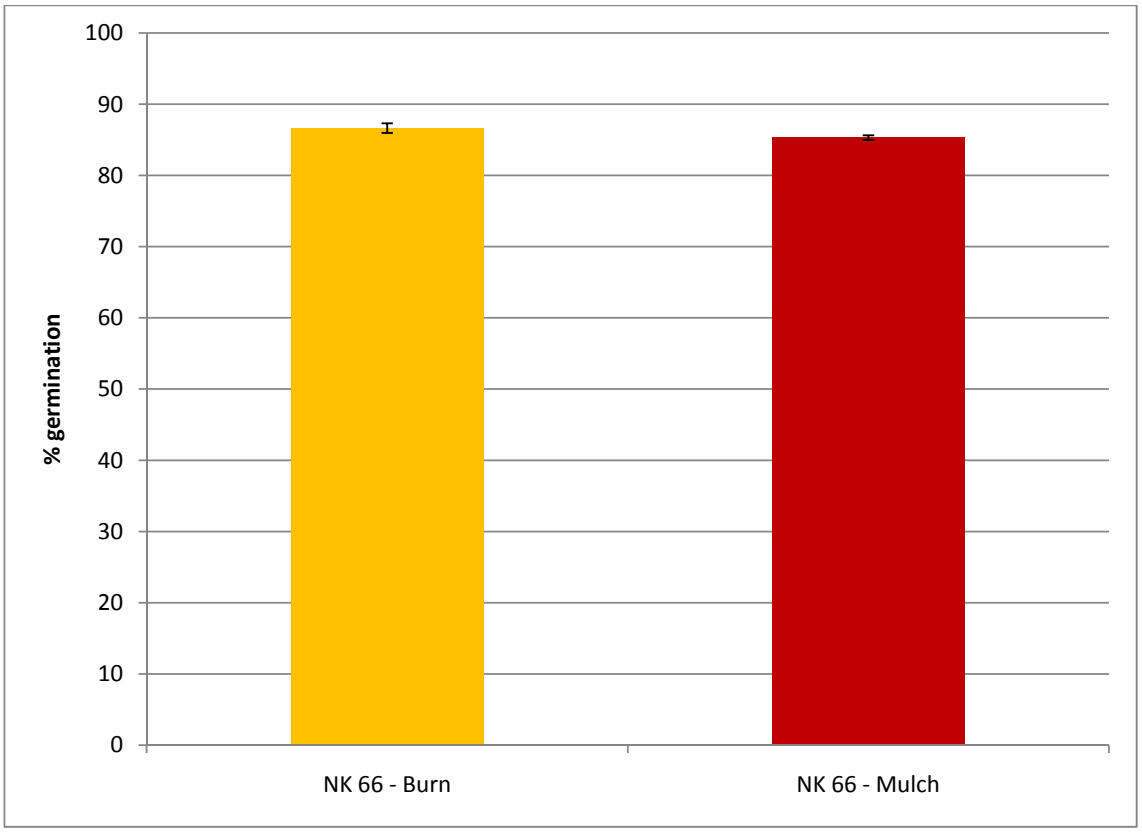
Development stage	**NK 66**		**NK 66 + M**	
	DAS	**Date**	**DAS**	**Date**
Sowing	0	11/04/10	0	11/04/2010
V3-4	12	23/04/10	11	22/04/2010
V7	29	10/05/10	26	07/05/2010
VT	58	08/06/10	54	04/06/2010
R1	68	18/06/10	66	16/06/2010
R3	78	28/06/10	75	25/06/2010
R5	88	08/07/10	85	05/07/2010
Harvest	104	24/07/10	101	21/07/2010

[1]DAS=Days after sowing

4.8.1.3.2 Germination rate

Germination rate ranged from 85 to 87 %. There were no significant differences between treatments in germination rate ($F_{1, 2}$ = 2.286, p=0.270) (Fig. 4.8.1.2).

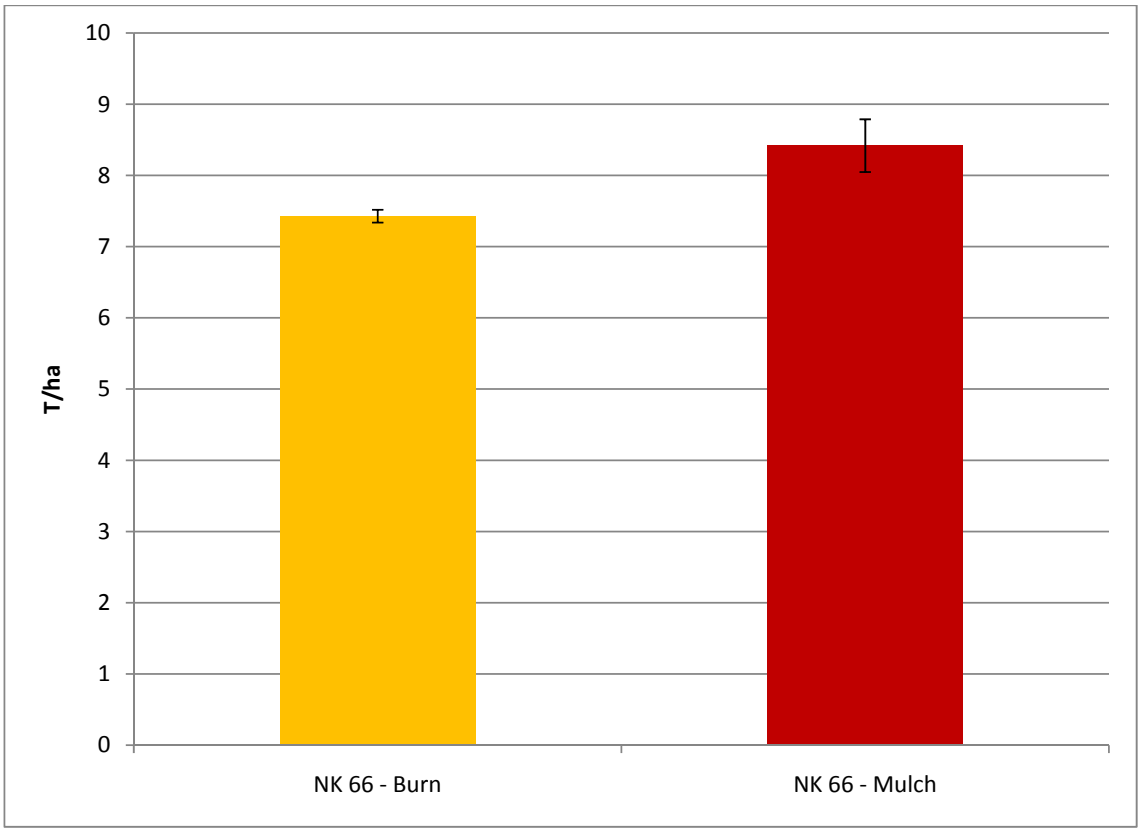
Figure 4.8.1.2: Germination rate of maize in different treatments



4.8.1.3.3 Yield

Yield ranged between 7.43 and 8.42 T/ha. There were no significant differences in yield between treatments ($F_{1, 2}$ = 5.904, p=0.136) (Fig. 4.8.1.3).

Figure 4.8.1.3: Yield of maize in different treatments



4.8.1.4 Conclusions and comments

Both treatments had very high yields. Use of mulch did not significantly influence yield.

4.8.2 Experiment 2: Influence of green mulch (intercropping with peanuts and soya beans) and mulch on maize productivity

4.8.2.1 Experimental objectives

The objective of the experiment was:

1. Evaluate the influence of green mulch (intercropping with peanuts and soya beans) and mulch on maize productivity

4.8.2.2 Materials and methods

4.8.2.2.1 Experimental design

The experiment was a randomised complete block design with 4 treatments and 3 replicates.

Treatments were:

1. Maize mono-crop no mulch (T1)
2. Maize mono-crop with mulch (T2)
3. Maize intercropped with peanut (T3)
4. Maize intercropped with soya bean (T4)

Each plot had an area of 100 m^2, with each block having an area of 400 m^2 making a total experimental area of approximately 1200 m^2 (Fig. 4.8.2.1).

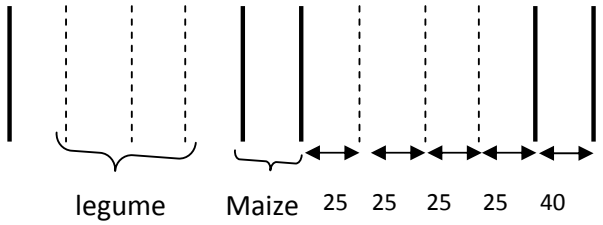
Fig 4.8.2.1: Schematic map of the experiment

T1	T2	T4	T3
T2	T3	T1	T4
T4	T2	T3	T1

4.8.2.2.2 Main cultivation activities

1. Sowing (11/04/2010). Maize hybrid NK66 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3). Peanut (unknown local variety) was sown at a depth of 0.05 m. Soya bean variety DT84 was sown at a depth of 0.05 m.

2. In treatments T3 and T4 (intercropping) maize was sown in strips of two rows of maize with a narrow spacing of 0.4 m. Spacing between 2 strips was 1 m. Legumes were sown in three rows 0.25 m apart into the 1m-space between two maize strips (see diagram below).



Fertiliser was added only to maize at the time of sowing in same trenches as seeds but at a depth of 0.15 m

3. First fertiliser dressing was applied on 08/05/10
4. First weeding was done on 08/05/10
5. Second fertiliser dressing was applied on 20/05/10
6. Second weeding was done on 20/05/10
7. Third fertiliser dressing was applied on 02/06/10
8. Third weeding was done on 02/06/10

4.8.2.2.3Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.8.2.1).

Table 4.8.2.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
11/04/2010	Superphosphate (18%)	500	3,000	1,500,000
08/05/2010/V6-7	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
20/05/2010/V9-11	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
02/06/2010/V14-15	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	**5,640,000**

4.8.2.3 Results

4.8.2.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.8.2.2 and Table 4.8.2.3 respectively.

Table 4.8.2.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
NK66	2.22 (0.04)	1.07 (0.01)	18.26 (0.24)	5.12 (0.05)	15.02 (0.08)	34.82 (0.67)	79	300

Table 4.8.2.3: Development of maize in Phieng Luong

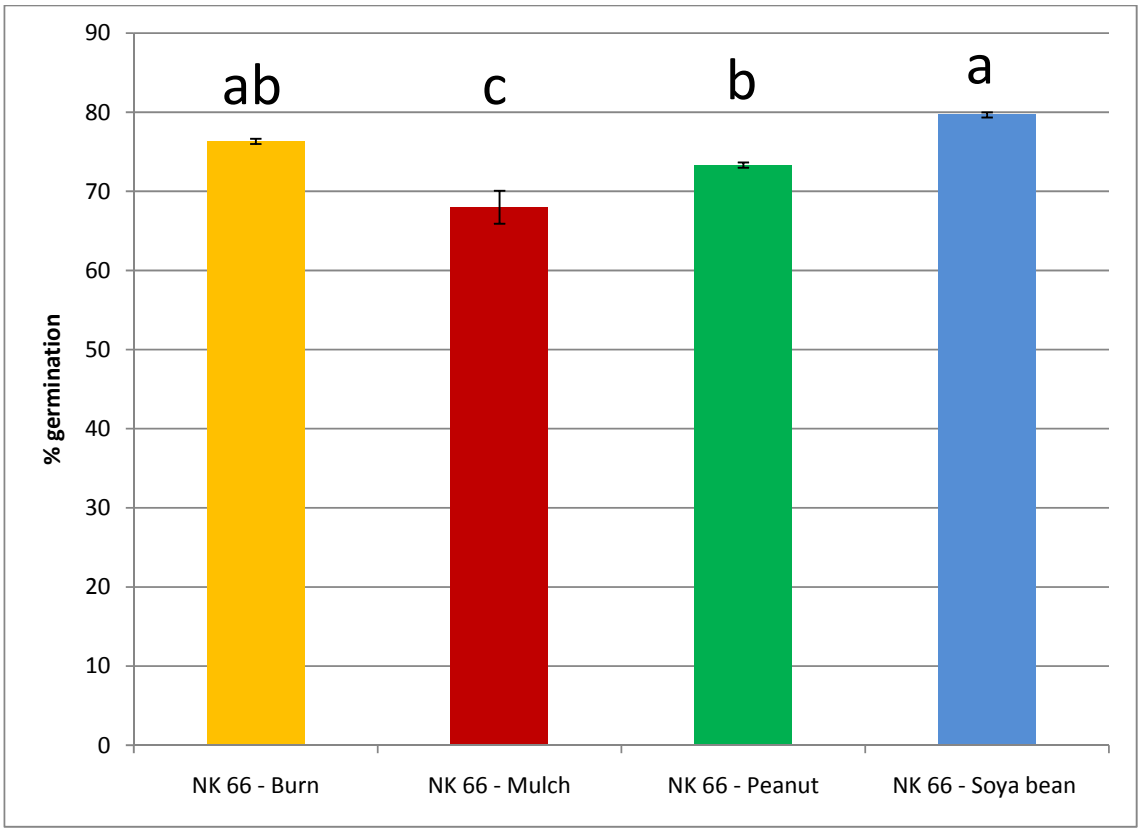
Development stage	**NK66**		**NK66 + M**		**NK66 + Peanut**		**NK66 + Soya bean**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	0	11/04/10	0	11/0410	0	11/04/10	0	11/04/10
V3-4	12	23/04/10	11	22/04/10	12	23/04/10	12	23/04/10
V5-6	17	28/04/10	16	27/04/10	17	28/04/10	17	28/04/10
VT	48	29/05/10	45	26/05/10	46	27/05/10	46	27/05/10
R1	67	17/06/10	66	16/06/10	67	17/06/10	66	16/06/10
R3	75	25/06/10	73	23/06/10	74	24/06/10	75	25/06/10
R5	85	05/07/10	82	02/07/10	84	04/07/10	84	04/07/10
Harvest	105	25/07/10	100	20/07/10	102	22/07/10	103	23/07/10

[1]DAS=Days after sowing

4.8.2.3.2 Germination rate

Germination rate ranged from 68 to 80 %. There were significant differences between treatments in germination rate ($F_{3,6}$ = 22.828, p=0.001) (Fig. 4.8.2.2). The germination rate of maize was significantly higher when intercropped with soya bean that when intercropped with peanut or when mulch was used. The germination rate of maize was significantly higher when maize was planted as a monocrop without mulch or when intercropped with peanut than when it was sown as a monocrop with mulch. Maize sown as a mono-crop with mulch had the statistically significant lowest germination rate.

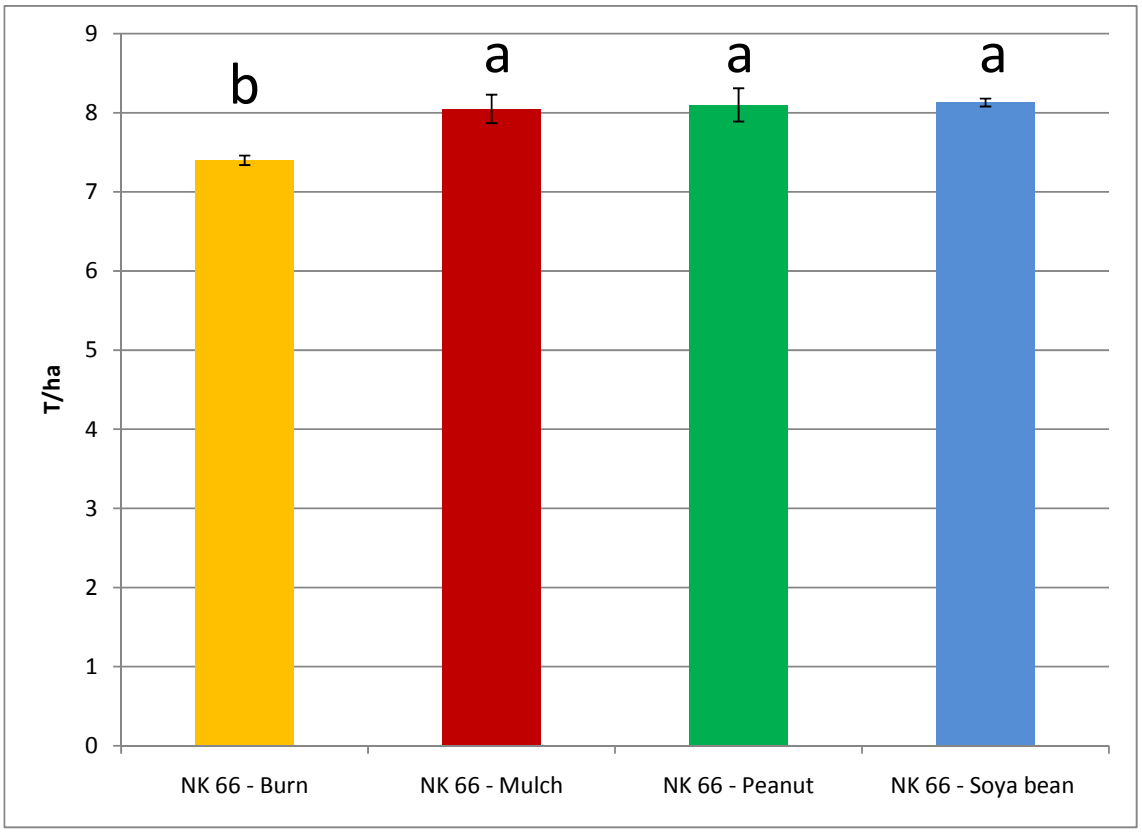
Figure 4.8.2.2: Germination rate of maize in different treatments



4.8.2.3.3 Yield

Yield ranged between 7.40 and 8.13 T/ha. There were significant differences in yield between treatments ($F_{3,6}$ = 4.893, p=0.047) (Fig. 4.8.2.3). Yield of maize sown as a monocrop without mulch was significantly lower than the yield in any other treatment. There were no significant differences between any other treatments.

Figure 4.8.2.3: Yield of maize in different treatments



4.8.2.4 Conclusions and comments

Results of this experiment are once again consistent with other experiments (4.4.1, 4.4.2, 4.6.2 and 4.7.3): intercropping with legumes had a positive effect on maize growth and results in higher yields. Similar to experiment 4.7.3 peanuts were harvested but the yield was low. Soya bean was destroyed by diseases.

4.9 Tay Bac Station – Son La

4.9.1 Experiment 1: Influence of intercropping with rice bean on maize productivity

4.9.1.1 Experimental objectives

The objective of the experiment was:

1. Evaluate the influence of intercropping with rice bean on maize productivity

4.9.1.2 Materials and methods

4.9.1.2.1 Experimental design

The experiment was a randomised complete block design with 2 treatments and 3 replicates.

Treatments were:

1. Maize mono-crop (T1)
2. Maize intercropped with rice bean (T2)

Each plot had an area of 100 m^2, with each block having an area of 200 m^2 making a total experimental area of approximately 600 m^2 (Fig. 4.9.1.1).

Fig 4.9.1.1: Schematic map of the experiment

T1	T2	T1	T2	T1	T2

4.9.1.2.2 Main cultivation activities

1. Sowing (01/05/2010). Maize hybrid LVN99 was sown in trenches at a depth of 0.05 m with 2 seeds per position and rice bean was sown together with the maize. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3).
2. Fertiliser was added only to maize at the time of sowing in same trenches as seeds but at a depth of 0.15 m
3. First fertiliser dressing was applied on 12/05/10
4. First weeding was done on 12/05/10
5. Second fertiliser dressing was applied on 02/06/10
6. Second weeding was done on 02/06/10
7. Third fertiliser dressing was applied on 20/06/10
8. Third weeding was done on 20/06/10

4.9.1.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.9.1.1).

Table 4.9.1.1: Time and amount of fertilisers applied

Date/ Development stage	**Fertiliser**	**Amount/ha (kg/ha)**	**Price/kg (VND)**	**Cost/ha (VND)**
01/05/2010 Sowing	Manure	10,000	300	300,000
	Superphosphate (18%)	400	3,000	1,200,000
12/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
02/06/2010V8-10	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
20/06/10/V12-13	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	**5,640,000**

4.9.1.3 Results

4.9.1.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.9.1.2 and Table 4.9.1.3 respectively.

Table 4.9.1.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN99	1.68 (0.02)	0.92 (0.02)	14.32 (0.19)	3.55 (0.02)	14.50 (0.11)	31.90 (0.63)	79	293

Table 4.9.1.3: Development of maize in Tay Bac Station

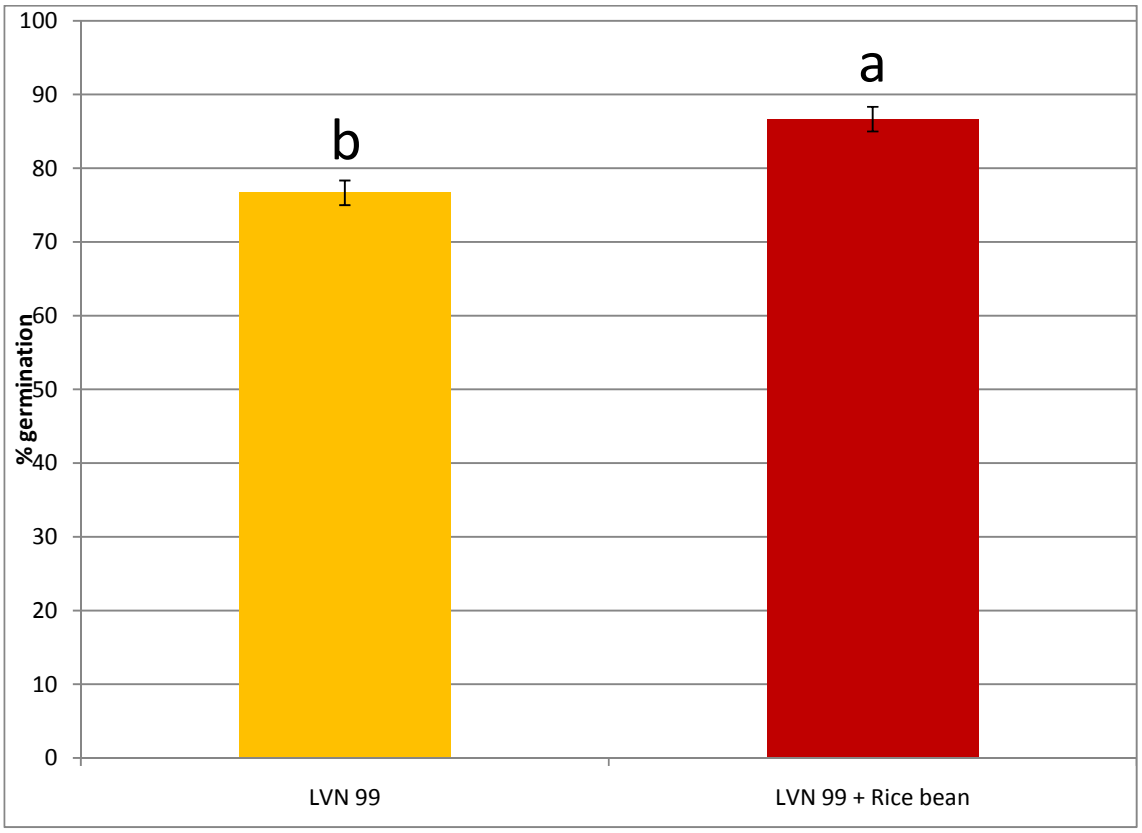
Development stage	**LVN99**		**LVN99 + Ricebean**	
	DAS	**Date**	**DAS**	**Date**
Sowing	0	01/05/10	0	01/05/10
V3-4	12	13/05/10	11	12/05/10
V7	46	16/06/10	47	17/06/10
VT	62	02/07/10	63	03/07/10
R1	76	16/07/10	77	17/07/10
R3	86	26/07/10	88	28/07/10
R5	96	05/08/10	97	06/08/10
Harvest	112	21/08/10	112	22/08/10

[1]DAS=Days after sowing

4.9.1.3.2 Germination rate

Germination rate ranged from 77 to 87 %. There were significant differences between treatments in germination rate ($F_{1,6}$ = 18.00, p=0.013) (Fig. 4.9.1.2). The germination rate of maize was significantly higher when intercropped with rice bean.

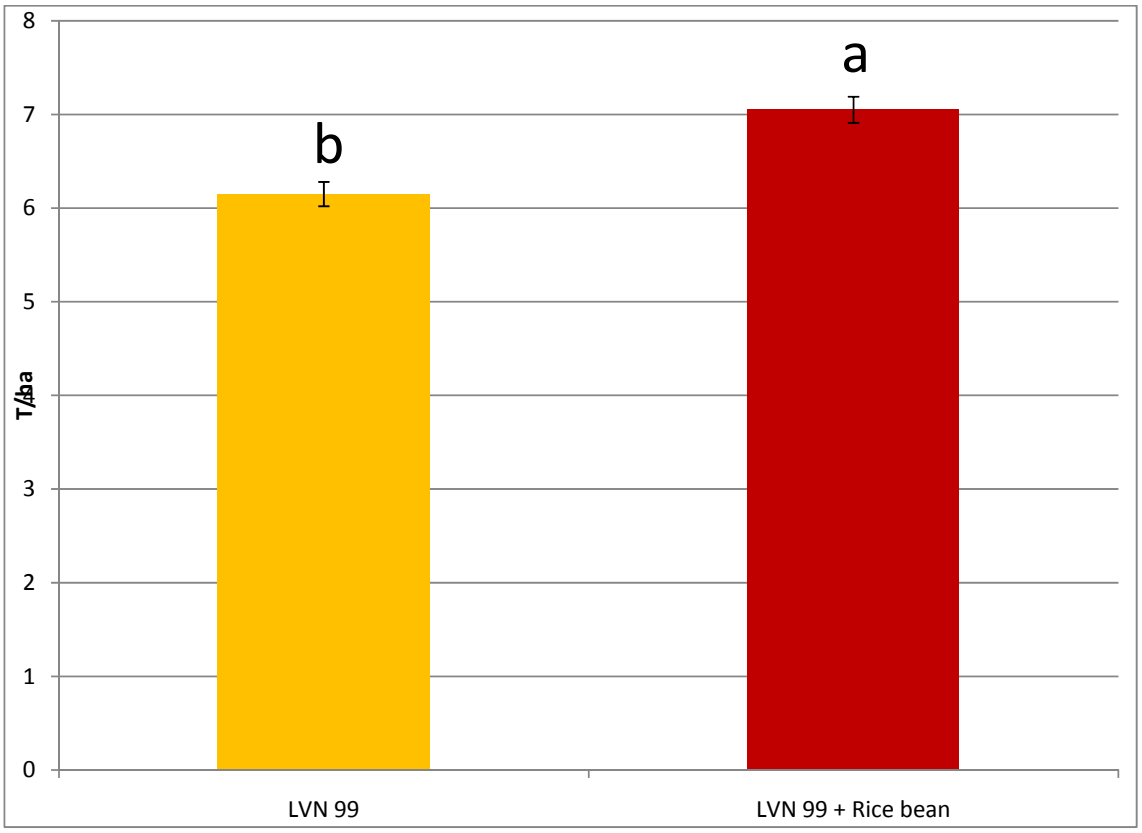
Figure 4.9.1.3: Germination rate of maize in different treatments



4.9.1.3.3 Yield

Yield ranged between 6.15 and 7.05 T/ha. There were significant differences in yield between treatments ($F_{1,2}$ = 18.380, p=0.050) (Fig. 4.9.1.3). Yield of maize was significantly higher when intercropped with rice bean.

Figure 4.9.1.3: Yield of maize in different treatments



4.9.1.4 Conclusions and comments

Rice bean was an unfamiliar crop for both the researchers and farmers in Son La province so the planting density used (which was similar to black beans) was too high resulting in crop failure before harvest. However, the legume crop had a positive effect on maize yield.

4.9.2 Experiment 2: Influence of intercropping with peanut and soya bean on maize productivity

4.9.2.1 Experimental objectives

The objective of the experiment was:

1. Evaluate the influence of intercropping with peanuts and soyabeans on maize productivity

4.9.2.2 Materials and methods

4.9.2.2.1 Experimental design

The experiment was a randomised complete block design with 3 treatments and 3 replicates.

Treatments were:

1. Maize mono-crop (T1)
2. Maize intercropped with peanut (T2)
3. Maize intercropped with soyabean (T3)

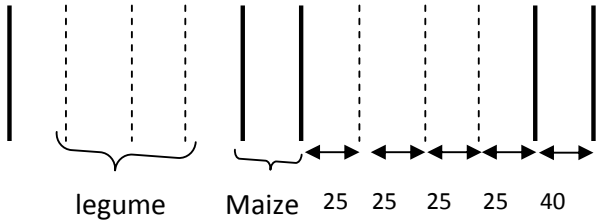
Each plot had an area of 100 m^2, with each block having an area of 300 m^2 making a total experimental area of approximately 900 m^2 (Fig. 4.9.2.1).

Fig 4.9.2.1: Schematic map of the experiment

T2	T1	T3	T1	T2	T3	T2	T3	T1

4.9.2.2.2 Main cultivation activities

1. Sowing (01/05/2010). Maize hybrid LVN146 was sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3). Peanut variety L14 was sown at a depth of 0.05 m. Soya bean variety DT84 was sown at a depth of 0.05 m.
2. In treatments T2 and T3 (intercropping) maize was sown in strips of two rows of maize with a narrow spacing of 0.4 m. Spacing between 2 strips was 1 m. Legumes were sown in three rows 0.25 m apart into the 1m-space between two maize strips (see diagram below).



3. Fertiliser was added only to maize at the time of sowing in same trenches as seeds but at a depth of 0.15 m
4. First fertiliser dressing was applied on 12/05/10
5. First weeding was done on 12/05/10
6. Second fertiliser dressing was applied on 02/06/10
7. Second weeding was done on 02/06/10
8. Third fertiliser dressing was applied on 20/06/10
9. Third weeding was done on 20/06/10

4.9.2.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.9.2.1).

Table 4.9.2.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
01/05/2010 Sowing	Manure	10,000	300	300,000
	Superphosphate (18%)	400	3,000	1,200,000
12/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	33	14,000	462,000
02/06/2010/V6-7	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	33	14,000	462,000
20/06/2010/V10-11	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	33	14,000	462,000
			Total cost	**4,464,000**

4.9.2.3 Results

4.9.2.3.1Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.9.2.2 and Table 4.9.2.3 respectively.

Table 4.9.2.2: Maize height characteristics at the R4 stage and other characteristics at harvest.

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN146	1.88 (0.05)	0.94 (0.03)	15.54 (0.36)	2.97 (0.05)	13.31 (0.12)	33.34 (0.45)	78	302

Table 4.9.2.3: Development of maize in Tay Bac Station

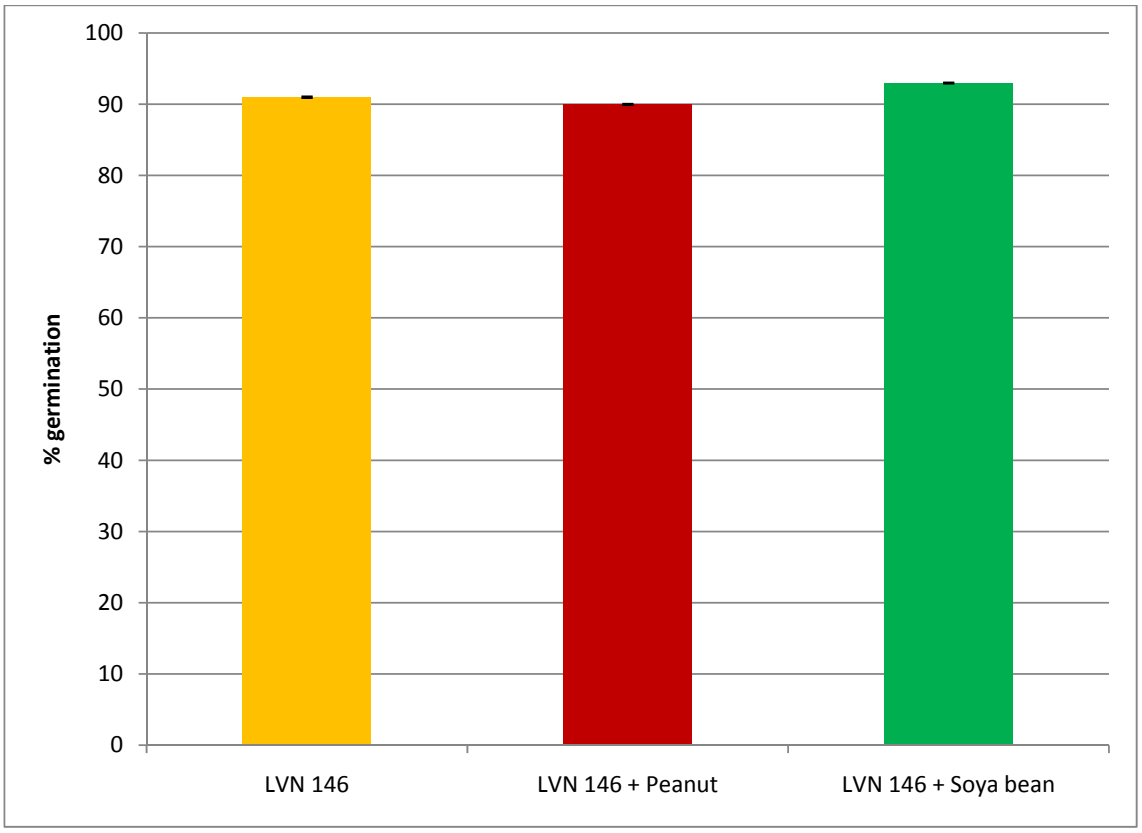
Development stage	**NK66**		**NK66 + Peanut**		**NK66 + Soya-bean**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	0	08/05/10	0	08/05/10	0	08/05/10
V3-4	13	21/05/10	13	21/05/10	12	20/05/10
V10-11	43	20/06/10	43	20/06/10	44	21/06/10
VT	64	11/07/10	64	11/07/10	62	09/07/10
R1	75	22/07/10	75	22/07/10	75	22/07/10
R3	84	31/07/10	84	31/07/10	84	31/07/10
R5	97	13/08/10	95	11/08/10	95	11/08/10
Harvest	106	22/08/10	105	21/08/10	105	21/08/10

[1]DAS=Days after sowing

4.9.2.3.2 Germination rate

Germination rate ranged from 90 to 93 %. There were no significant differences between treatments in germination rate ($F_{2,4}$ = 3.818, p=0.118) (Fig. 4.9.2.2).

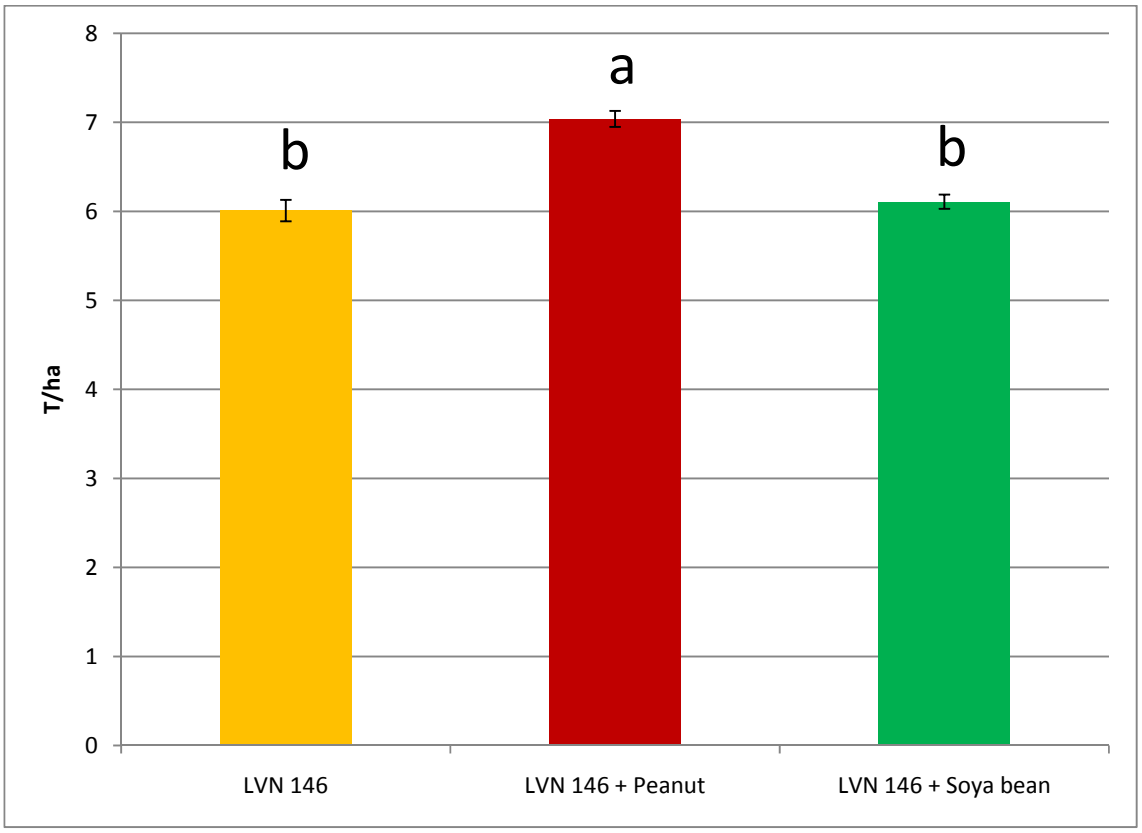
Figure 4.9.2.2: Germination rate of maize in different treatments



4.9.2.3.3 Yield

Yield ranged between 6.01 and 7.05 T/ha. There were significant differences in yield between treatments ($F_{2, 4}$ = 25.349, p=0.005) (Fig. 4.9.2.3). Yield of maize when intercropped with peanut was significantly higher than when it was sown as a monocrop or when intercropped with soybean.

Figure 4.9.2.3: Yield of maize in different treatments



4.9.2.4 Conclusions and comments

Even though this experiment was done at research station the soya bean crop was lost to diseases by the end of the season. Peanuts were harvested but the yield was low. Results of this experiment are once again consistent with other experiments ((4.4.1, 4.4.2, 4.6.2 4.7.3 and 4.8.1): intercropping with legumes had a positive effect on maize growth and results in higher yield.

4.9.3 Experiment 3: Evaluation of eight maize varieties

4.9.3.1 Experimental objectives

The objective of the experiment was to compare maize varieties with the standard LVN10.

4.9.3.2 Material and methods

4.9.3.2.1 Experimental design

The experiment was designed as a randomized complete block with 8 treatments and 3 replicates.

Treatments were:

1. LVN99 (T1)
2. LVN146 (T2)
3. LVN154 (T3)
4. LCH9 (T4)
5. Sweet10 (T5)
6. SweetLD20 (T6)
7. White maize1 (T7)
8. LVN10 standard (T8)

Each plot had an area of 100 m^2, with each block having an area of 800 m^2 making a total experimental area of 2400 m^2 (Fig. 4.9.3.1).

Fig 4.9.3.1: Schematic map of the experiment

T4	T8	T5	T7	T3	T6	T1	T2
T8	T3	T6	T2	T4	T5	T7	T1
T2	T8	T7	T1	T5	T3	T6	T4

4.9.3.2.2 Main cultivation activities

1. Sowing (30/04/2010). All maize varieties were sown in trenches at a depth of 0.05 m with 2 seeds per position. Distance between rows was 0.7 m and distance between sowing positions within the row was 0.3 m (0.7x0.3)
2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. First fertiliser dressing was applied on 12/05/10
4. First weeding was done on 12/05/10
5. Second fertiliser dressing was applied on 02/06/10
6. Second weeding was done on 02/06/10
7. Third fertiliser dressing was applied on 20/06/10
8. Third weeding was done on 20/06/10

4.9.3.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.9.3.1).

Table 4.9.3.1: Time and amount of fertilisers applied

Date/ Development stage	Fertiliser	Amount/ha (kg/ha)	Price/kg (VND)	Cost/ha (VND)
30/04/2010/Sowing	Manure	10,000	300	300,000
	Superphosphate (18%)	400	3,000	1,200,000
12/05/2010/V3-4	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
02/06/2010/V6-7	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
20/06/2010/V10-11	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	**5,640,000**

4.9.3.3 Results

4.9.3.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.9.3.2 and Table 4.9.3.3 respectively.

Table 4.9.3.2: Maize characteristics

	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
LVN99	1.73 (0.02)	0.89 (0.06)	16.10 (0.57)	4.56 (0.06)	15.13 (0.35)	32.63 (2.42)	81	300
LVN146	1.74 (0.08)	0.82 (0.04)	17.55 (0.26)	4.76 (0.04)	14.80 (0.23)	33.90 (0.45)	80	305
LVN154	1.63 (0.06)	0.84 (0.02)	17.75 (0.54)	4.45 (0.08)	14.60 (0.12)	33.73 (0.92)	79	297
LCH9	1.79 (0.05)	0.91 (0.06)	16.13 (0.54)	4.60 (0.04)	15.20 (0.23)	32.63 (1.22)	78	310
LVN10	1.72 (0.01)	0.86 (0.02)	16.10 (0.23)	4.32 (0.08)	13.47 (0.07)	33.90 (0.29)	82	295

Table 4.9.3.3: Development of maize in Tay Bac Station

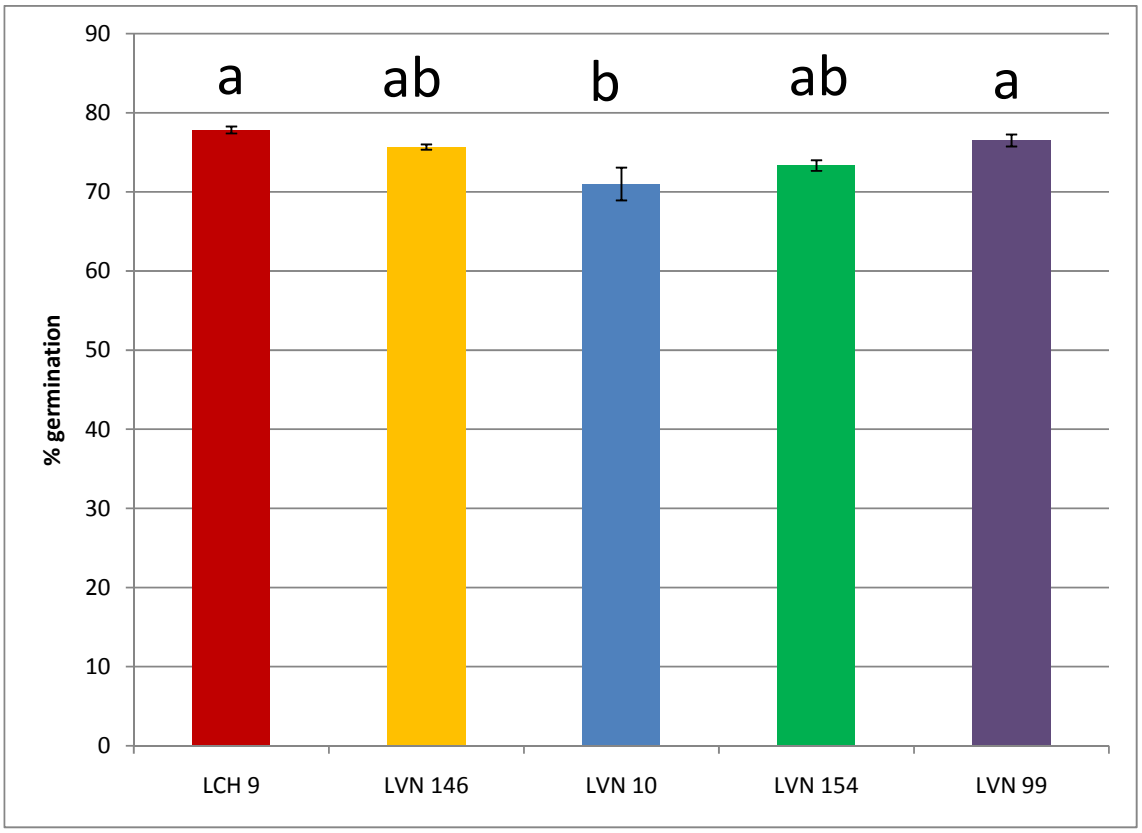
Development stage	LVN 154		LVN 146		LCH 9		LVN 99		LVN 10	
	DAS	Date	DAS	Date	DAS	Date	DAS	Date	DAS	Date
Sowing	0	01/05/10	0	01/05/10	0	01/05/10	0	01/05/10	0	01/05/10
V3-4	11	12/05/10	11	12/05/10	11	12/05/10	10	11/05/10	12	13/05/10
V10	48	18/06/10	47	17/06/10	47	17/06/10	47	17/06/10	48	18/06/10
VT	64	04/07/10	63	03/07/10	63	03/07/10	61	01/07/10	65	05/07/10
R1	76	16/07/10	77	17/07/10	75	15/07/10	74	14/07/10	78	18/07/10
R3	87	26/07/10	87	26/07/10	86	26/07/10	85	25/07/10	90	30/07/10
R5	97	06/08/10	97	06/08/10	96	05/08/10	95	04/08/10	101	10/08/10
Harvest	112	21/08/10	112	21/08/10	111	20/08/10	110	19/08/10	118	27/08/10

[1]DAS=Days after sowing

4.9.3.3.2 Germination rate

Germination rate ranged from 71 to 78 %. There were significant differences between treatments in germination rate ($F_{4, 8}$ = 5.908, p=0.016) (Fig. 4.9.3.2). Germination rates of maize variety LCH9 and LVN99 were statistically significantly higher than that of the standard variety LVN10. There were no significant differences between other varieties.

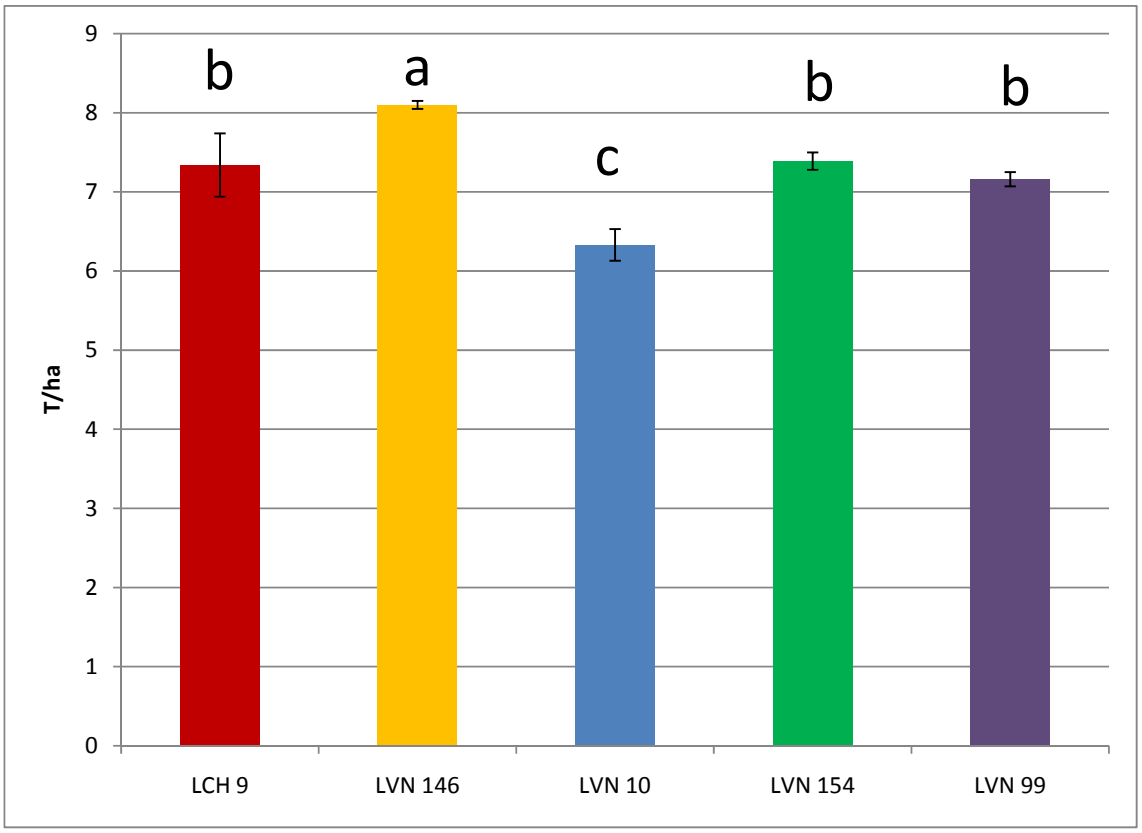
Figure 4.9.3.2: Germination rate of maize in different treatments



4.9.3.3.3 Yield

Yield ranged between 6.33 and 8.10 T/ha. There were significant differences in yield between treatments ($F_{4, 8}$ = 50.086, p<0.001). All varieties had significantly higher yield than the standard variety LVN10. Maize variety LVN146 had significantly higher yield than all other varieties. There were no significant differences between varieties LVN99, LVN54 and LCH9. Results are presented in Figure 4.9.3.3.

Figure 4.9.3.3: Yield of maize in different treatments



4.9.3.4 Conclusions and comments

Results from this experiment are not entirely consistent with the results of experiment 4.6.1 where the same varieties were evaluated in farmers' fields. In experiment 4.6.1 variety LVN146 had significantly lower yield than varieties LCH9 and LVN99 while in this experiment it is significantly the highest yielding variety. However in both experiments varieties LCH9 and LVN99 performed significantly better than the benchmark variety LVN10.

The main inconsistencies between experiments are results for the length of maize development from sowing to harvest. Varieties LCH9, LVN99, LVN146 and LVN154 had respectively 17, 18, 21 and 18 days longer development time than in experiment 4.6.1. So although results from experiment 4.6.1 indicate these varieties are suitable for use in a 2-crop per season system, this experiment indicates that further testing is necessary before we can make conclusions.

4.9.4 Experiment 4: Evaluation of high plant density on maize productivity

4.9.4.1 Experimental objectives

The objective of the experiment was to evaluate impact of high planting density on maize productivity.

4.9.4.2 Material and methods

4.9.4.2.1 Experimental design

The experiment was designed as a randomized complete block with 4 treatments and 3 replicates.

Treatments were:

1. Maize sown at density of 54,000 plant/ha – Common practice in NW (T1)
2. Maize sown at density of 65,000 plant/ha (T2)
3. Maize sown at density of 70,000 plant/ha (T3)
4. Maize sown at density of 75,000 plant/ha (T4)

Each plot had an area of 225 m^2, with each block having an area of 900 m^2 making a total experimental area of 2700 m^2 (Fig. 4.9.4.1).

Fig 4.9.4.1: Schematic map of the experiment

65.000/ha	70.000/ha	75.000/ha	54.000/ha
54.000/ha	65.000/ha	70.000/ha	75.000/ha
70.000/ha	75.000/ha	54.000/ha	65.000/ha

4.9.4.2.2 Main cultivation activities

1. Sowing (01/05/2010). Maize variety LVN61 was sown in trenches at a depth of 0.05 m with 2 seeds per position. For planting density of:
    a. 54,000 plants/ha distance between rows was 0.70 m and distance between sowing positions within the row was 0.25 m (0.70x0.25)
    b. 65,000 plants/ha distance between rows was 0.60 m and distance between sowing positions within the row was 0.25 m (0.60x0.25)
    c. 70,000 plants/ha distance between rows was 0.55 m and distance between sowing positions within the row was 0.25 m (0.55x0.25)

d. 75,000 plants/ha distance between rows was 0.45 m and distance between sowing positions within the row was 0.30 m (0.45x0.30)

2. Fertiliser was added at the time of sowing in same trenches as seeds but at depth of 0.15 m
3. First fertiliser dressing was applied on 12/05/10
4. First weeding was done on 12/05/10
5. Second fertiliser dressing was applied on 02/06/10
6. Second weeding was done on 02/06/10
7. Third fertiliser dressing was applied on 20/06/10
8. Third weeding was done on 20/06/10

4.9.4.2.3 Fertiliser application

Time and amount of fertilisers applied was determined according to guidelines from the Maize Institute (Table 4.9.3.1).

Table 4.9.4.1: Time and amount of fertilisers applied

Date/ Development stage	**Fertiliser**	**Amount/ha (kg/ha)**	**Price/kg (VND)**	**Cost/ha (VND)**
01/05/2010 Sowing	Manure	10,000	300	300,000
	Superphosphate (18%)	400	3,000	1,200,000
12/05/2010/V2-3	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
02/06/2010V8-10	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
20/06/2010/V12-13	Urea (46% N)	100	6,800	680,000
	Kaliclorua (52% K)	50	14,000	700,000
			Total cost	5,640,000

4.9.4.3 Results

4.9.4.3.1 Maize characteristics and development stages

Maize characteristics and development stages of the crop are presented in Table 4.9.4.2 and Table 4.9.4.3 respectively.

Table 4.9.4.2: Maize characteristics

LVN 61	Height (m)		Cob (cm)		Number of		W seed/ W cob (%)	W (g) 1000 seeds
	Plant	1st cob	Length	Diameter	Rows	Seeds per row		
54,000	1.92 (0.08)	1.04 (0.03)	18.23 (0.62)	4.94 (0.19)	14.80 (0.20)	37.43 (0.87)	77	295
65,000	1.93 (0.06)	1.07 (0.06)	19.20 (0.40)	4.99 (0.09)	16.20 (0.12)	38.97 (0.47)	77	296
70,000	1.98 (0.03)	1.11 (0.02)	19.26 (0.39)	4.91 (0.06)	16.46 (0.13)	38.33 (0.62)	76	296
75,000	1.97 (0.02)	1.10 (0.04)	19.92 (0.01)	4.93 (0.13)	16.67 (0.24)	40.10 (0.35)	77	296

Table 4.9.4.3: Development of maize in Tay Bac Station

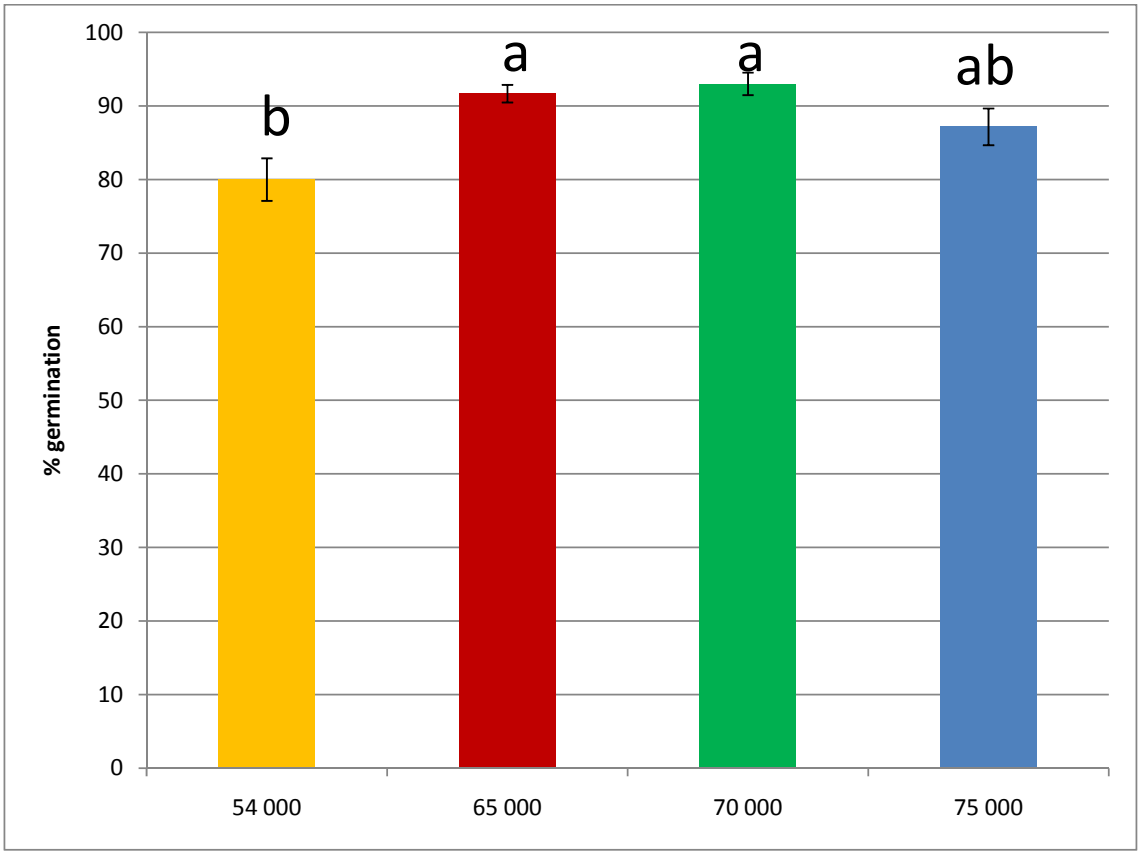
Development stage	**54000 seed/ha**		**65000 seed/ha**		**70000 seed/ha**		**75000 seed/ha**	
	DAS	**Date**	**DAS**	**Date**	**DAS**	**Date**	**DAS**	**Date**
Sowing	0	01/05/10	0	01/05/10	0	01/05/10	0	01/05/10
V3-4	12	13/05/10	12	13/05/10	11	12/05/10	12	13/05/10
V7	48	18/06/10	48	18/06/10	46	16/06/10	48	18/06/10
VT	62	02/07/10	62	02/07/10	61	01/07/10	62	02/07/10
R1	75	15/07/10	75	15/07/10	72	12/07/10	74	14/07/10
R3	88	28/07/10	88	28/07/10	85	25/07/10	86	26/07/10
R5	102	11/08/10	101	10/08/10	100	09/08/10	100	09/08/10
Harvest	112	21/08/10	112	21/08/10	111	20/08/10	111	20/08/10

[1]DAS=Days after sowing

4.9.3.3.2 Germination rate

Germination rate ranged from 80 to 93 %. There were significant differences between treatments in germination rate ($F_{3, 6}$ = 5.675, p=0.035) (Fig. 4.9.4.2). Germination rates of maize sown at density of 65,000 and 70,000 plants per hectare were statistically significantly higher than that of the standard density of 54,000. Germination rate of maize sown at density of 75,000 plants per hectare was not significantly different from any other treatment.

Figure 4.9.4.2: Germination rate of maize in different treatments



4.9.4.3.3 Yield

Yield ranged between 7.97 and 10.49 T/ha. There were significant differences in yield between treatments ($F_{3, 6}$ = 68.639, p<0.001). Yield of maize sown at the highest density of 75,000 plants/ha was statistically significantly the highest yield achieved in the experiment. Maize sown at density of 70,000 plants/ha recorded second highest yield, which was significantly higher than yield recorded at two lower densities. There were no significant differences in yield recorded for two lower planting densities. Results are presented in Figure 4.9.4.3. Regression analysis shows that there is significant positive linear relationship between yield and plant density R^2 = 0.79 ($F_{1, 10}$ = 36.411, p<0.001) (Fig 4.9.4.4).

Figure 4.9.4.3: Yield of maize in different treatments

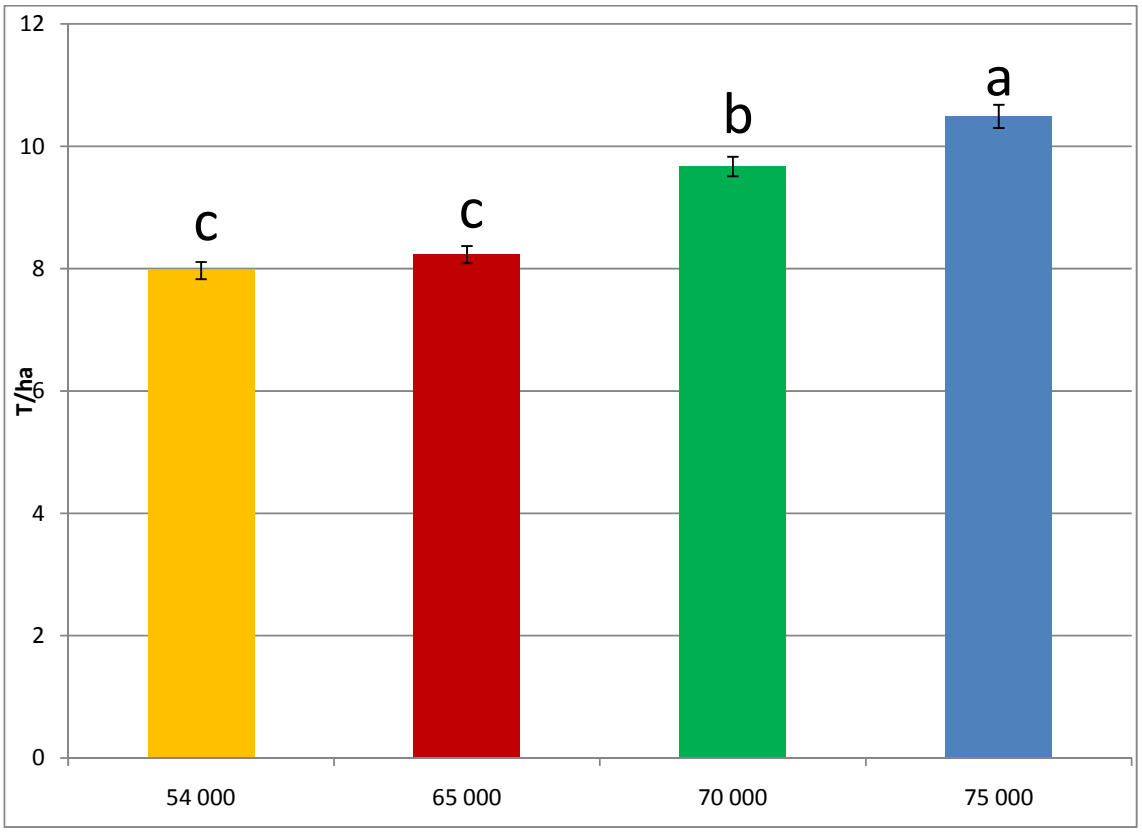
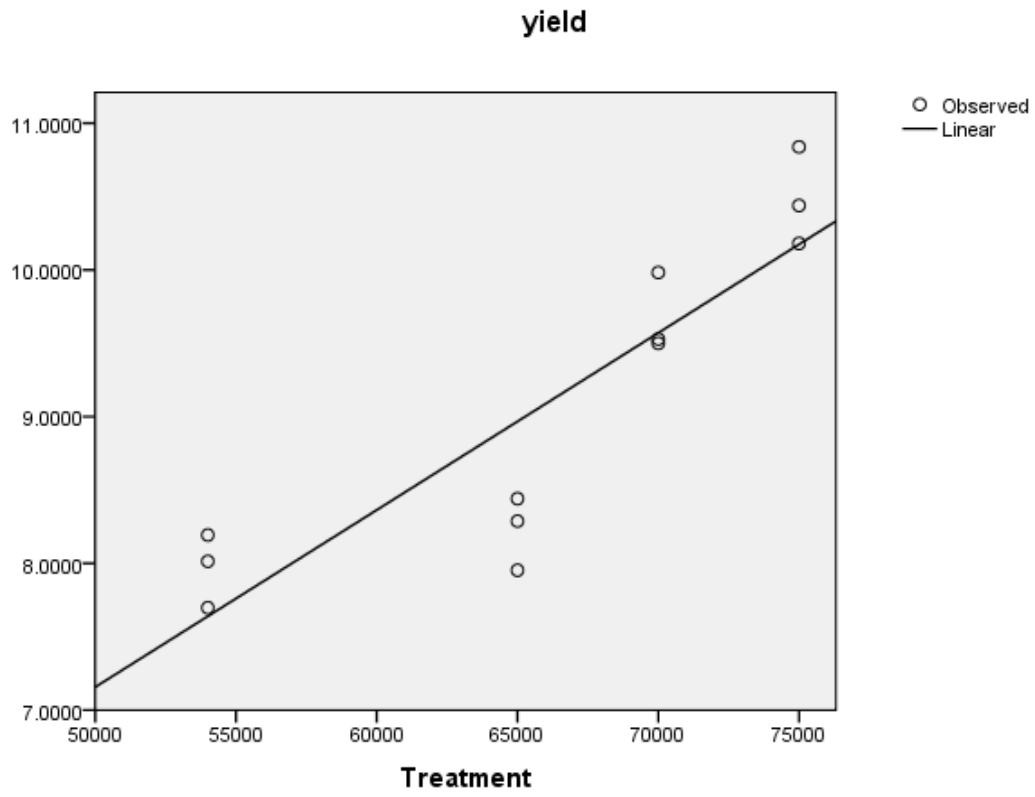


Figure 4.9.4.4: relationship between planting density and yield



4.9.4.4 Conclusions and comments

There was significant linear relationship between planting density and yield. Results indicate that a significant increase in yield can be achieved with increased planting density under high fertiliser use. Modes of incorporating higher planting density in farmer's .practice have to be further investigated.