Chapter V Maize Production and Constraints

This chapter is considered as body part of this study, which divided into two sections. The first section described the characteristics of maize production system. The second section identified and prioritized the yielding constraint that involved in the maize field in growing reason and then quantitative assessment was employed to estimate the contribution of each yielding constraint to yield reduction in the whole area.

5.1 Maize production

5.1.1 Land use for maize and land characteristics

Population and food demand increasing that forced agricultural production in the rainfed area more intensive. A vast of forest area in the steepland was cut down to devote for agricultural land. Following this trend, land use for maize was also expanded rapidly. The result of transect walk showed that maize has been not only grown in the flatland, midland area, but also expanded up to the steepland area (Figure 9).

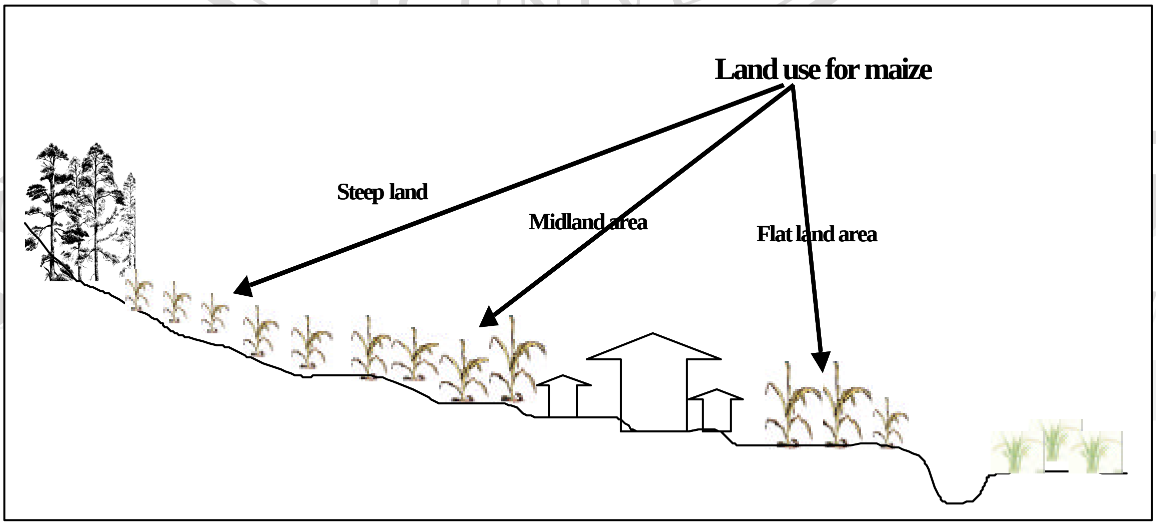


Figure 9: Transect of land use for maize production in upland area

The transect routine was selected how to describe fully the characteristics and current situation of land and soil in the upland area with direction from the East to the West of village. During transect walk farmers were required for both observation and discussion to describe the characteristics, advantage, disadvantage of each land type. The efforts of farmers in describing the current land and soil characteristics were presented in Table 9.

Table 9 Farmer's classification on potential zones for maize production

Zones	Description	Advantages	Disadvantages
Flatland area (Most suitable area)	Slope: Flat or less than 10^0 Soil depth more than 1m Color: Black, gray color Rich organic matter High soil fertility Good soil texture Sandy- loam soil High porosity	Small erosion Easy to work Produces good yield, even inadequate rain Average water holding capacity	Pests and diseases Drought stress, if no rain in long-periods Somewhere have affected by erosion Difficult to farm because of need more input
Midland area (Moderately suitable area)	Slope: ranging from 10-20^0 Soil depth: from 0.5-1m Color: Grey, brow, and yellow color Loamy, clay-loam Medium organic mater Medium soil fertility Mixture of fine and coarse-grained	Can be produce good yield if rains are good Respond well to fertilizers Average holding water capacity	Erosion affected yield Low soil fertility Drought Difficult to plow in upper parts Pests and disease Weed competition Need more inputs
Steepland area (Less suitable area)	Slope: more than 20^0 Soil depth: less than 0.5m Color: Yellow color Poor to medium organic matter Clay-loam, clay, heavy clay Coarse –grained High compact Low soil fertility		Erode easily Waterlogged easily Poor soil Heavy drought Difficult to plow Need more inputs

Source: survey, 2002.

The results (Table 9) showed that the soil texture changed from sandy loam in the flatland to clay loam in the midland and clay loam, clay and heavy clay in the steepland area. The organic matter content in the soil also changed from the rich in the flatland to poor in the steepland area. The changes in soil texture and organic matters that made the soil quality in villages to be changed, from good soil in the flatland to poor soil in the steepland area. Evaluation of the cause of this problem, all of farmer agreed that this was result of soil erosion that made the soil fertility declined rapidly in the steepland and midland where have been strongly affected by eroding while the sediment in erosion process mostly accumulated in the flatland and valleys that is reason why the soil quality in the flatland area and valleys is better than the midland and steepland area.

The opportunity for maize production was evaluated through the advantage and disadvantage of each land type (Table 9). It noted that the disadvantages were mostly concentrated in the steepland and midland, which consisted of drought, soil erosion, low soil fertility and difficulty in land preparation etc that strongly affected maize productivity. However, the stress level of yielding constraints to maize productivity were different in each land type, the most serious problems were concentrated in the steepland area and follow by the midland area. These effects were considered as major causes leaded to the yield gap among land types and regions. Base on the actual yield was obtained, the effect level of constraint and soil quality, farmers evaluated the potential for maize production as follow: the most suitable area is flatland and valleys, follow by midland is moderate suitable area and the less suitable is steepland area.

Making statistics land area for maize production in each land type through farmer classification. The land areas devoted for maize production in four villages in the upland area were presented in Table 10.

Table 10 Land area for maize production in different parts of upland in four villages

Topography	Unit	Ang		Ban Hoa		Co Noi		Chieng Ban	
		Amount	%	Amount	%	Amount	%	Amount	%
Total area	ha	250.0	100.0	70.0	100.0	1,180.00	100.0	375.4	100.0
- Steep land (Less suitable)	ha	8.5	3.4	15.5	22.1	32.5	2.75	18.6	4.9
- Mid land (Mode- suitable	ha	215.8	86.3	43.0	61.4	786.9	66.6	334.1	88.9
- Flat land (Most suitable)	ha	25.7	10.2	11.5	16.4	360.6	30.5	22.7	6.0

Source: survey, 2002

Comparing maize production area among surveyed villages, Table 10 showed that largest maize area in Coi Noi is 1,180.0 ha, follow by Chieng Ban 375.0 ha, Ang 250.0 ha and Ban Hoa 70.0 ha, which annually have been using for maize production. The data (Table 10) also indicated that mostly maize was produced in the midland area, of which Chieng Ban was 88.9 percent, Ang was 86.3 percent, Conoi was 66.6 percent and Ban Hoa was 61.4 percent of the total maize area of each village.

The most suitable area for maize growth was located in the flatland area and narrow valleys. In Ang village, this land type occupied about 10.2 percent; Ban Hoa 16.4 percent, and Co Noi 22.7 percent and Chieng Ban 6.0 percent of total maize area of each village. The steep land was considered as the less suitable area for maize, the maize area in this land type in Ang was 3.4 percent, Ban Hoa was 22.1 percent, and Co Noi was 2.7 percent and Chieng Ban was 4.9 percent of total maize area of village.

5.1.2 Maize variety

The result of survey showed that before 1987, almost of farmers used local varieties consisted of white maize and yellow maize varieties. These varieties applied widely in this period, which occupied from 80 to 85 percent of maize areas in the province.

In the period of 1987-1993, farmers applied both local varieties and open-pollinated varieties (OPVs). The OPVs were used, which consisted of MSB 49, TSB1 (Suwan 1), TSB2 (Suwan 2), which were imported from CIMMYT. The local varieties at that period covered about 45 percent and OPVs covered about 55 percent of the maize areas in the province.

In period of 1994-2002, the hybrid maize varieties were widely applied in production, which consisted of LVN10, DK 999, Bioseed 681, 96-98. The average yield of these varieties was higher as compare with local varieties and OPVs. Hence, the local varieties and OPVs were only planted with small area due to farmer lack of credit source to buy new varieties, which covered from 7 to 10 percent of the total maize area.

5.1.3 Types of maize production

In the past, in Son la province, maize was only produced as self-sufficient purposes. Recently, the demand of maize for feed industry increased rapidly. In 1997, it required about 560.000 tons of maize and this requirement could be increase one and half time in the first years of this decade (Khiem *et al*., On line). Therefore, the maize production in the north provinces, such as Son La, Ha Giang, Hoa Binh was shifted from subsistence toward semi-commercial production type with purpose to meet the demand of the feed industry sector as well as make more the income of maize growers. The result of field survey on the current trend of maize production in villages was presented in Table 11.

Table 11 Types of maize production in four villages

Type of production	Farmer households n= 30							
	Ang		Ban Hoa		Co Noi		Chieng Ban	
	No.hh	%	No.hh	%	No.hh	%	No.hh	%
Semi-commercial (No. of household)	20.0	66.6	14.0	46.7	24.0	80.0	11.0	36.7
Subsistence (No. of household)	10.0	33.3	16.0	53.3	6.0	20.0	17.0	63.3

Source: survey, 2002

The data (Table 11) showed that most of maize growers in Ang and Co Noi village produced maize under semi-commercial type, which was 66.6 percent and 80.0 percent of maize growers, respectively while the percentage of maize growers produced maize under this productive type in Ban Hoa and Chieng Ban village was only 46.7 percent and 36.7 percent, respectively. The grain after harvesting mainly provided to the industry of feed animal processing, which accounted for 80 to 90 percent of total maize product and home consumption for livestock was only about 10 to 20 percent. The rest of farmer households produced maize under subsistence, the product mostly used for the home consumption, livestock and local market.

5.1.4 Inputs use for maize production

5.1.4.1 Seed

The amount of seed used was different among varieties: local varieties from 28.5 to 31.0 kg per hectare of seed, OPVs from 26.0 to 28.0 kg per hectare and hybrid varieties from 19.0 to 23.6 kg per hectare of seed. Accounting for seed used in farmer practice in above, it was quite high as compare with Truong *et al*. (2000) amount of seed uses from 15 to 16 kg per hectare. For this, most of maize growers agreed that increase in amount of seed use could maintain the density of plant per ha in case germinate rate was lower than expectation. Looking the variation in terms of seed use, the standard value of seed among villages noted that variation in amount of seed used among farmer households under investigation was quite small (Table 12, 13,14).

5.1.4.2 Fertilizers application

In maize production, investigation showed that farmers mostly used chemical fertilizers, which consisted of nitrogen (urea 46 percent), phosphorous, (super phosphate 17.6 percent) and potassium (potassium sulfate 60 percent), the FYM was not used in maize production because FYM was only applied for rice in the lowland. The results of survey (Table 12,13,14) noted that all of households did not applied fertilizers for local varieties under cultivation. The chemical fertilizers were mainly used for OPVs and hybrid varieties. However, the level of fertilizer application among varieties and land used types were different. Making comparison of fertilizer used between varieties, it showed that amount of chemical fertilizers used for hybrid varieties were higher than OPVs in surveyed villages. Fertilizer use in the in the midland is an example, for the hybrid varieties, the average amount of nitrogen used from 92.4 to 107.7 kg per hectare, phosphorous from 43.0 to 53.2 kg per hectare and potassium from 55.5 to 60.8 kg per hectare. While the amount of fertilizers used for OPVs: nitrogen from 62.1 to 87.4 kg per hectare, phosphorous from 30.5 to 36.8 kg per hectare, potassium from 37.0 to 50.2 kg per hectare. This trend also exists in the flatland and steepland area.

In addition, making comparison of amount of fertilizers used for maize among the parts of the upland area, the surveyed results indicated that the amount of fertilizers used for maize (both OPVs and hybrid varieties) in the flatland and midland area was higher than the amount of fertilizers used in the steepland area. Because the maize production in the midland, flatland was more intensity and has been orienting toward semi-commercial and commercial production types.

Comparison of amount of fertilizer used for maize among farmer households, the standard deviation value of each kind of fertilizer used for maize was quite high (Table 12,13,14). It means that variation in amount of chemical fertilizers applied for maize among farmer households was quite different. The main reasons of this problem are lack of credit sources, technology and traditional cultivation techniques, which have effected the variation in fertilization in maize production.

5.1.4.3 Pesticides use

Insects and diseases usually occur and damage the growth rate of maize and maize yield. The major insects were earworm, cut worm, stem border etc that could appear and damage at any growth stage of maize during growing season. The injured level depends on the particular insect and disease and the growth stage of maize. According to farmer voices, the most serious of insects were cutworm and earthworm that could destroy the entire maize field at early growth stage if control practice was not pay attended to. To minimize the damage of insects and diseases, all of maize growers used chemical pesticides with high frequency. The common pesticides were used by farmers were Padan 95 SP, Sherpa 25 EC, Alphacy 5EC and Vadilaxin etc. Comparison of pesticides used among land types in terms of money (VND) (Table 12, 13,14). It indicated that amount of pesticides used in the flatland and midland area was higher than in the steepland area because these areas maize were produced as semi-commercial and commercial types so beside the high fertilization rate, pesticides also used with high rate to maintain the yield.

Table 12: Average inputs used for maize in the steepland area

Locations	Units	Moc chau				Mai son			
		Ang		Ban Hoa		Co Noi		Chieng Ban	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
- *Local varieties*									
Seed	kg/ha	28.4	6.1	31.1	4.6	-	-	31.0	5.6
Nitrogen	kg/ha	0.0	0.0	0.0	0.0	-	-	0.0	0.0
Phosphorous	kg/ha	0.0	0.0	0.0	0.0	-	-	0.0	0.0
Potassium	kg/ha	0.0	0.0	0.0	0.0	-	-	0.0	0.0
Pesticides	VND	0.00	0.0	0.0	0.0	-	-	0.0	0.0
Labor	m-day	121.5	15.5	124.2	24.1	-	-	135.0	38.1
- *OPVs*									
Seed	kg/ha	28.3	2.7	29.6	10.6	26.1	2.8	28.3	4.6
Nitrogen	kg/ha	40.3	29.4	45.7	24.7	38.3	31.5	31.1	37.3
Phosphorous	kg/ha	26.7	20.9	25.2	27.8	25.7	25.1	20.1	23.4
Potassium	kg/ha	20.1	24.3	37.8	41.8	22.4	29.3	20.1	24.1
Pesticides	VND	0.0	0.0	0.0	0.00	153.0	149.5	0.0	0.0
Labor	m-day	162.0	38.1	139.5	31.5	166.0	50.2	160.7	13.5
- *Hybrid*									
Seed	kg/ha	23.6	3.7	21.7	2.8	20.5	4.5	23.7	4.8
Nitrogen	kg/ha	51.8	42.6	57.3	44.7	62.1	41.2	59.6	38.7
Phosphorous	kg/ha	30.1	23.4	28.5	24.7	29.5	27.8	26.6	24.6
Potassium	kg/ha	33.3	31.7	37.4	45.1	38.9	37.3	30.3	33.6
Pesticides	VND	0.0	0.0	105.9	113.8	167.4	105.2	151.2	149.8
Labor	m-day	168.0	37.64	166.5	44.78	156.6	35.2	175.6	53.9

Source: Survey, 2002

Table 13: Average inputs used for maize in the midland area

Locations	Units	Moc chau				Mai son			
		Ang		Ban Hoa		Co Noi		Chieng Ban	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
- OPVs									
Seed	kg/ha	28.4	2.6	25.3	6.14	26.5	3.7	28.1	3.0
Nitrogen	kg/ha	74.5	33.4	64.7	33.2	87.4	42.7	62.1	30.4
Phosphorous	kg/ha	35.9	26.2	36.8	17.9	35.0	33.7	30.5	22.1
Potassium	kg/ha	48.6	34.1	50.2	23.2	39.8	40.3	37.0	26.3
Pesticides	VND	131.14	106.21	101.5	93.3	204.3	176.26	131.14	128.0
Labor	m-day	181.9	25.6	148.0	38.8	173.7	48.94	181.29	37.6
- Hybrid									
Seed	kg/ha	20.2	2.50	19.9	3.10	24.1	3.7	21.7	5.2
Nitrogen	kg/ha	104.1	32.5	85.8	26.2	92.4	51.8	107.7	20.6
Phosphorous	kg/ha	50.3	26.3	53.2	13.3	46.9	29.4	43.0	28.4
Potassium	kg/ha	59.7	25.6	59.9	19.5	60.8	38.5	55.5	37.3
Pesticides	VND	209.0	88.7	189.0	137.6	226.3	165.5	211.0	141.5
Labor	m-day	192.3	33.6	183.6	44.3	180.3	25.7	198.2	30.4

Source: Survey, 2002

Table 14. Average inputs used for maize in the flatland area

Locations	Units	Moc chau				Mai son			
		Ang		Ban Hoa		Co Noi		Chieng Ban	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
- OPVs									
Seed	kg/ha	29.7	2.9	28.3	5.6	25.3	2.9	28.08	2.4
Nitrogen	kg/ha	79.7	31.5	66.8	31.1	88.5	41.2	79.5	20.8
Phosphorous	kg/ha	38.0	21.7	39.5	26.2	45.7	19.9	37.1	21.9
Potassium	kg/ha	50.0	41.1	54.7	28.3	43.5	38.0	42.1	25.2
Pesticides	VND	139.5	116.3	131.6	116.74	138.3	88.3	140.4	130.0
Labor	m-day	175.5	47.5	165.3	33.65	175.5	38.1	178.2	30.7
- Hybrid									
Seed	kg/ha	22.25	3.37	21.37	2.43	24.03	3.47	22.73	3.35
Nitrogen	kg/ha	114.9	22.9	115.7	14.7	113.0	42.8	116.5	24.8
Phosphorous	kg/ha	59.5	22.9	73.3	27.4	48.9	26.7	53.0	17.8
Potassium	kg/ha	66.8	21.9	67.9	22.8	63.3	35.4	64.5	33.6
Pesticides	VND	310.5	149.4	280.0	105.7	275.4	167.7	290.2	120.2
Labor	m-day	213.7	35.4	198.0	40.4	199.8	46.2	218.2	24.3

Source: Survey, 2002

5.1.4.4 Labor use

Labor used in maize production included in land preparing, sowing, weeding, insecticide spraying and harvesting. Total labor used for maize production varied following production types and locations. In the steepland area, maize was produces as subsistence, traditional techniques, no fertilization, minimum tillage etc were applied so that number of man-day per hectare varied from 121 to 160 man-day per hectare. However, in the midland and flatland area, most of farmer produced maize under semi-commercial types so that labor force used was quite higher from 170 to 216 man day per hectare including land preparation, sowing, weeding and pest control (Table 12,13,14).

5.1.5 Farmers' field practices in maize production

5.1.5.1 Distribution of maize growers in terms of fertilize use

In this part, we try to descript the proportion of farmer used fertilizers in each land type (Table 15) with purpose to make more clearly the picture of fertilizers used for maize by farmer households.

The result showed that having 60 percent of farmers in the steepland area used chemical fertilizers under the average level (70-85 kgper hectare), of which has 30.4 percent of farmer non -applied nitrogen, 41.3 percent of farmer non applied phosphorus and 47.8 percent of farmer non-applied potassium while in midland, there were only 5.3 percent of framer non applied nitrogen, 22.8 percent of farmer non applied phosphorous and 26.3 percent of framer non applied potassium. In the flatland, percentage of farmer non-fertilization was lowest, which has only 4.1 percent of farmer non-applied nitrogen, 13.7 percent of farmer non-applied phosphorus and non-applied potassium 15.1 percent of framer households. For this problem, farmers mean that the lack of credit source was major cause leading to non-fertilization for maize.

In the midland and flatland area, amount of fertilizers were invested more for maize. In term of nitrogen application, there were 51.4 percent of farmer in the midland and 78.1 percent of farmer in the flatland had used nitrogen higher from the average level (85-120 kg per hectare), of which has 22.8 percent in the midland and 41.1 percent of framer in the flatland who used nitrogen falling in the recommended rates (120-150 kg per hectare) while in the steepland all of farmer has used lower than the recommendation rate, of which was only 19.6 percent of farmer used nitrogen higher the average level (70-120 kg per hectare).

Table 15. Distribution of farmer households in fertilizer used in three land types

Level of Fertilizers	Steepland (n=46)		Midland (n=57)		Flatland (n=73)	
	No.hh	%	No.hh	%	No.hh	%
Nitrogen (kg/ha)						
0	14.0	30.4	3.0	5.3	3.0	4.1
0-70	16.0	34.8	12.0	21.1	8.0	11.0
70-85 N	7.0	15.2	7.0	12.3	5.0	6.8
85-120	9.0	19.6	22.0	38.6	27.0	37.0
120-150 *	0.0	0.0	13.0	22.8	30.0	41.1
Phosphorous (kg/ha)						
0	19.0	41.3	13.0	22.8	10.0	13.7
0-40	10.0	21.7	4.0	7.0	3.0	4.1
40-50	10.0	21.7	14.0	24.6	12.0	16.4
50-75	7.0	15.2	26.0	45.6	37.0	50.7
75-90 *	0.0	0.0	0.0	0.0	11.0	15.1
Potassium (kg/ha)						
0	22.0	47.8	15.0	26.3	11.0	15.1
0- 45	8.0	17.4	2.0	3.5	5.0	6.8
45-55	3.0	6.5	2.0	3.5	3.0	4.1
55-80	13.0	28.3	15.0	26.3	29.0	39.7
80-100 *	0.0	0.0	23.0	40.4	25.0	34.2

*Source: Survey, 2002. note: * recommendation rate*

In terms of phosphorous use for maize, there were 15.2 percent in the steepland, 45.6 percent in the midland and 65.8 percent in the flatland of farmer households used phosphorous over the average level (50-50 kg per hectare), of which has 15.1 percent of farmer in the flatland used phosphorous falling in recommendation rate (75-90 kg per hectare) while in the steepland and midland, all of farmers used phosphorous under the recommendation rate.

Evaluating framers used potassium for maize; Table 15 showed that there was 28.3 percent of farmer in the steepland used potassium more than the average level (45- 55 kg per hectare) while in the midland there was 66.7 percent of farmer and flatland 73.9 percent of farmer. Of which was 40.4 percent of farmer in the midland and 34.2 percent of farmer in the flatland used potassium falling in the recommendation rates.

5.1.5.2 Farmers' field practices

Land preparation: Except for the steepland area, in the flatland and a part of the midland area, land preparation was done by the cattle power, the plowing and harrowing times depend on available labor and animal power in particular farmer households. The data (Table 16) showed that the average plowing times in villages varied from 1.3 to 1.5 times and harrowing varied from 1.2 to 1.3 times, which were conducted before sowing.

Fertilize application: fertilizers were applied from 1 to 3 times during growing season, which depends on farm characteristics and their capacity. Two times of fertilizer application was popularity in this area (Table 16). The first time was applied before sowing, amount of fertilizer applied were 100 percent of phosphorous and 30-40 percent of nitrogen and 30-40 percent of potassium, the rest of fertilizers were applied at the second time, which fall into 10-15 days before the flowering stage. Some farmer households applied three times of fertilization for maize, it depends on the status of maize and their capacity.

Weeding and pest management: Weeding and pest control were conducted in growing season depending on the frequency of pest appearance and weed density on the maize field. At the flatland and midland area, farmer more pay attention to pest and weed control than in the steepland area so that money used for pesticides and labor used in these areas were often higher than as compare with the steepland area. The data under investigation (Table 16) showed that the average weeding time was from 2.1 to 2.3 times per crop. Normally, farmer conducted two times of weeding control during growing season and in order to eliminate weed competition, a number of farmers conducted three times of weed control per crop. However, a number of farmer households only conducted one of weeding due to lack of labor or they were reluctant with farm management so that in these farms, the interplant interaction was unavoidable and damage to yield has get higher level as compare with the farms were conducted from two and three times of weeding. For pest control, pest control could be concerned in all of times of growing season, but mostly focus on the early stage of maize and before flowering time because in these stages, pest could heavily damage to the maize yield. As the result of field survey, the average of pest control times varied from 1.8 to 2.0 times in growing season.

Table 16 Farmers' field practice in maize production

Activities	Farmer's respondents							
	Ang		Ban Hoa		Conoi		Chieng ban	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
- Plowing times	1.37	0.49	1.46	0.68	1.52	0.51	1.57	0.50
- Harrowing times	1.20	0.41	1.23	0.43	1.31	0.47	1.34	0.48
-Planting type	Sowing	-	Sowing	-	Sowing	-	Sowing	-
-Fertilizers application times	2.00	0.83	2.06	0.90	1.82	0.93	2.10	0.84
- Weeding times	2.13	0.78	2.36	0.85	2.14	0.88	2.10	0.71
- Pest control times	1.80	0.71	2.07	1.42	1.68	1.31	2.0	1.42
Soil conservation methods								
- Making terrace	-	-	-	-	-	-	-	-
- Green hedgerow	-	-	-	-	-	-	-	-
- Non-soil conservation	*	-	*	-	*	-	*	-
Crop residue used								
- Incorporate	-	-	-	-	-	-	-	-
- Burning	+	-	+	-	+	-	+	-
- Take out	-	-	-	-	-	-	-	-

*Source: Survey, 2002. note: * Non soil conservation method, + Crop residues was burnt at the field*

Soil conservation: Soil conservation is considered a precondition to ensure for agricultural production in slopping land more sustainable because when soil conservation methods applied that can reduce soil loss and nutrients out of system under heavy rain in the rainy season. Unfortunately, the result of field survey within villages showed that all of maize growers in this area did not applied any soil conservation methods in production, although they knew that soil erosion has strongly affected the maize field and made yield loss in the steepland and midland area.

Crop residues: Crop residues play an important role in terms of improving the nutrient cycle at the field through mass of organic matter return into the soil, if it is incorporated, in annually. Incorporating the crop residues in the soil will improve the soil status, especially, in the topsoil layer, such as soil organic matter content, nutrient elements, soil texture, soil structure and soil moisture etc when these characteristics are improved, which could support for crop growth better than in the next crops cycle. The result of field survey indicated that all crop residues were burnt at the field after harvesting time or before land preparation (Table 16) or took out of the field and used as fuel wood in home. This is major limitation in terms of maintaining and improving soil fertility for sustainable in maize production.

5.1.6 Maize yield and yield gap analysis

5.1.6.1 Maize yield

The maize yield may vary from year to year or site-to-site, the actual yield obtain depends on many conditions, such as the status of soil, water regime, nutrient application rate, management practice and other environmental impacts. The actual yields at the farm and yield gap often fully reflect the productive performances and existing limitations involve in the farms, which also are basics for analyzing and evaluating the their impact to maize production. The results of field survey, results of t-test (Appendix Tables #) showed that the maize yield among varieties and the parts of the upland area was different (Table 17).

Data (Table 17) indicated that the yield of local variety obtained very low, which varies from 1.1 ton per hectare in Chieng Ban to 1.4 tons per hectare in Ban Hoa, for this problem, it could be explained by the characteristics of varieties. Other varieties, such as hybrid varieties and OPVs, the yield was obtained higher from 1.5 to 4.5 times as compare with local varieties, it depends on varieties and locations. Particularly, the average yield of OPVs was obtained from 1.9 to 3.2 tons per hectare and with hybrid varieties; the average yield was obtained from 2.1 tons per hectare to 6.3 tons per hectare.

Table 17 Maize yield on different land types in the upland area

Items	Moc Chau				Mai Son			
	Ang		Ban Hoa		Co Noi		Chieng Ban	
	tons/ha	SD	tons/ha	SD	tons/ha	SD	tons/ha	SD
Steep land								
Local varieties	1.2	0.3	1.4	0.2	-	-	1.1	0.1
OPVs	1.9	0.4	1.7	0.1	1.5	0.4	1.9	0.4
Hybrid	2.6	0.6	2.1	0.4	2.4	1.3	2.5	0.7
Midland								
OPVs	2.7	1.3	2.9	0.8	2.5	0.8	2.6	0.7
Hybrid	4.1	1.0	3.9	1.5	4.0	1.3	4.3	1.4
Flatland								
OPVs	3.2	1.4	3.1	0.9	3.0	0.8	2.9	1.1
Hybrid	6.3	1.2	5.4	1.1	5.8	1.5	5.7	1.2

Source: Survey, 200.

Making comparison of average yield obtained from different land types data in Table 16 showed that the highest yield usually obtained at the flatland area, in which average yield of OPVs varied from 3.0 to 3.1 tons per hectare and hybrid varieties varied from 5.4 to 6.3 tons per hectare. The second is midland area, the average yield of OPVs varied from 2.5 to 2.9 tons per hectare and the yield of hybrid varieties varied from 3.9 to 4.3 tons per hectare. The lowest yield occurred in the steepland area, the average yield of OPVs varied from 1.5 to 1.9 tons per hectare and average yield of hybrid varieties varied from 2.1 to 2.6 tons per hectare across villages.

5.1.6.2 Yield gap analysis

Yield gap analysis is very useful in identifying the constraints to agricultural production. For this study, the yield gap analysis was applied for identifying the yielding constraints in maize production and simultaneously to evaluate the effect of the yielding constraints to maize productivity.

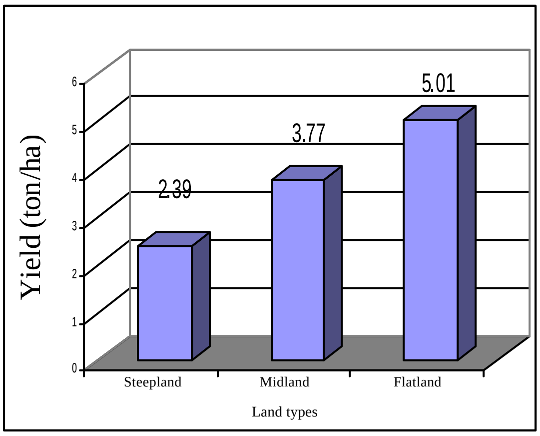
Figure 10 showed that the average maize yield obtained in each land types, the average yield in the steepland area was 2.39 tons per hectare, in the midland was 3.77 tons per hectare and in the flatland area was 5.01 tons per hectare. Thus, the yield gap between flatland and steep land was 3.62 tons per hectare, between flatland and midland was 1.24 tons per hectare, and the yield gap between the midland and steepland area was 1.38 tons per hectare. The original reasons leaded to these gaps are topography, soil quality, and inputs used and technological limitations. Because of in the steepland and the high parts of midland areas, soil erosion has more seriously. Consequences of soil erosion are changes in the topsoil layer for both physical and chemical characteristics, such as declining in soil fertility, soil texture, soil structure, water regime, pH etc, which leaded to the difference in terms of soil fertility among land types. Even in the same a land type, the degree of erosion effect on plots was different that made the soil characteristics have been negatively changed as compare with unaffected plots. These changes are considered as major cause of the yield gap between land types and farmer farms. Moreover, the difference in applying new technology in production of farmer among land types and farmer households that also leaded to yield gap in these areas.

Making comparison of the maize yield in different varieties (Figure 11) indicated that in the whole area, the average yield of hybrid varieties was 4.37 tons per hectare while the average yield of OPVs was 2.53 tons per hectare and yield of local varieties was 1.35 tons per hectare. Accounting for yield gap between varieties (Figure 11) also indicated that the gap between hybrid and local varieties was largest 3.02 tons per hectare, between hybrid and OPVs was 1.84 tons per hectare between and between OPVs and local varieties was only 1.18 tons per hectare. Thus, the difference in varieties used was also as a major cause leaded to the yield gap among locations and farmer households in this study site.

The yield gap was not only appeared in different land types and varieties, it also occurred at the same location through yield obtained among farmer households. The Figure 12, Figure 13 and Figure 14 addressed the yield gap and the percentage of farmer households has obtained maize yield in different level. In the steepland, percentage of farmer household obtained yield less than 2.0 tons per hectare was 28.2 percent (figure 12), the major causes of the low yield at these farms was result of the effect of yielding constraints involved in the maize field, of which, drought, soil erosion and non fertilizer use. There were 50.0 percent farmer households get yield from 2.0 to 3.0 tons per hectare and 21.8 percent of maize growers get yield more than 3.0 tons per hectare. The higher yield at these farms thanked to the lower stress of soil erosion and hybrid varieties as well as fertilizers were used in production.

In the midland area, there were 7 percent of maize grower obtained yield less than 2 tons per hectare, the maize yield from 2.0 to 3.0 tons per hectare was 28 percent and yield from 3.0 to 4.0 tons per hectare was 24.6 percent of maize growers have achieved (Figure 13). However, the percentage of maize growers obtained yield more than 4.0 tons per hectare was 40.4 percent, the high yield achieved in this area that had thanked to the hybrid varieties and chemical fertilizers were applied highly under the semi-commercial maize production. Moreover, the effective level of soil erosion was lower than as compare with the steepland area.

In the flatland area, the high yield obtained is thanked to the good the natural conditions. In addition, most of maize growers in this area produced maize under the semi-commercial and commercial production with high inputs level so that most of maize grower get yield more than 3.0 tons per hectare (Figure 14), in which has 52.1 percent of maize growers who obtained more than 5.0 tons per hectare. However, there were still 16 percent of maize grower get less than 3.0 tons per hectare that was quite low as compare with other farms in this area. The major causes of this problem were low inputs used, OPVs and erosion, which occurred at their farms and made yield return in these farms was lower.



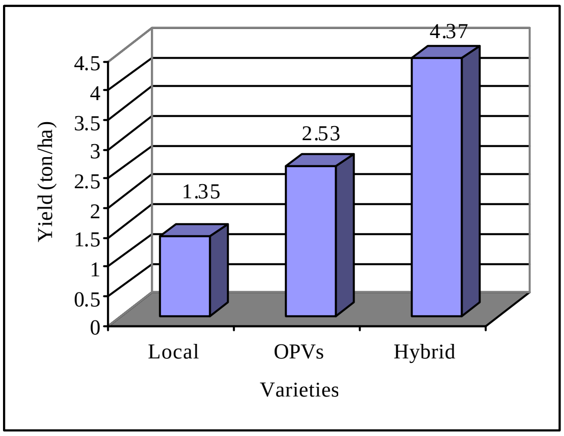
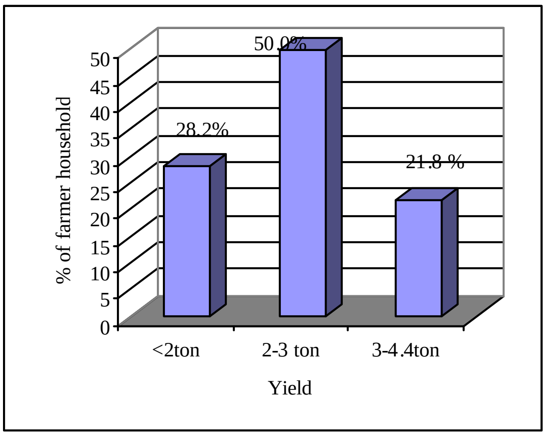


Figure 10: The yield gap among land types Figure 11. The yield gap among varieties



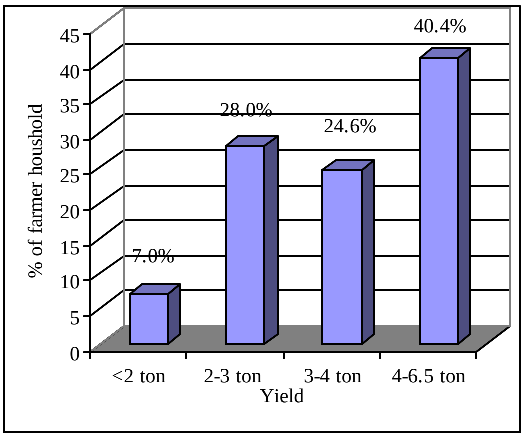


Figure12: Yield distribution in steepland Figure 13.Yield distribution in midland

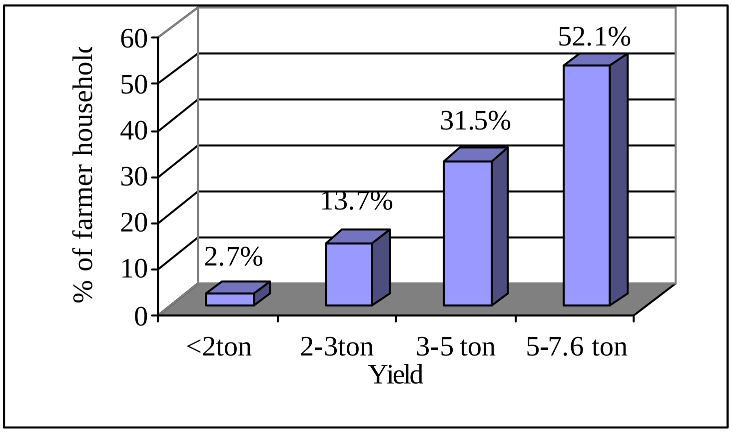


Figure 14. Yield distribution in the flatland

5.2 Constraints to maize productivity

5.2.1 Constraints identification

The yield gap analysis just initially pointed out the major problems, which involved in maize production and parallel answered a question what constraint factors affected maize productivity leading to the yield gap among parts of the upland area. To make more clearly the effect of constraints as well as its interactions in the maize production system, the participatory approach was employed in PRA workshop to analyse and evaluate the effects of yielding constraints. In PRA workshop, participants were divided into three groups, each group responsibility for identifying problems and making the causal diagram or tree problems to express the interaction of constraints that involved in maize system at the particular land type. Brainstorming exercise was used in identifying and analysing the cause and effect of constraints to maize productivity. In this process, farmers were required to think and determine both the primary and secondary yielding constraints what farmers faced in maize growing season.

Under support of study team the frame of causal diagram was set up and then farmers filled up the constraints into diagram, it consisted of the primary and secondary yielding constraints. The result of three groups in terms of determining the yielding constraints and its interaction were sum up in figure 15 (Causal diagram of constraints affected maize yield).

In the steepland area, farmers' group discussion found out five primary constraints involved to maize production, which included drought, soil erosion, old varieties, low fertilizer use and lack of technologies. These primary constraints have affected by the secondary constraints, which are deforestation, high slope, heavy rain, traditional cultivation technique, shortage of cash, and poor extension service and illiteracy.

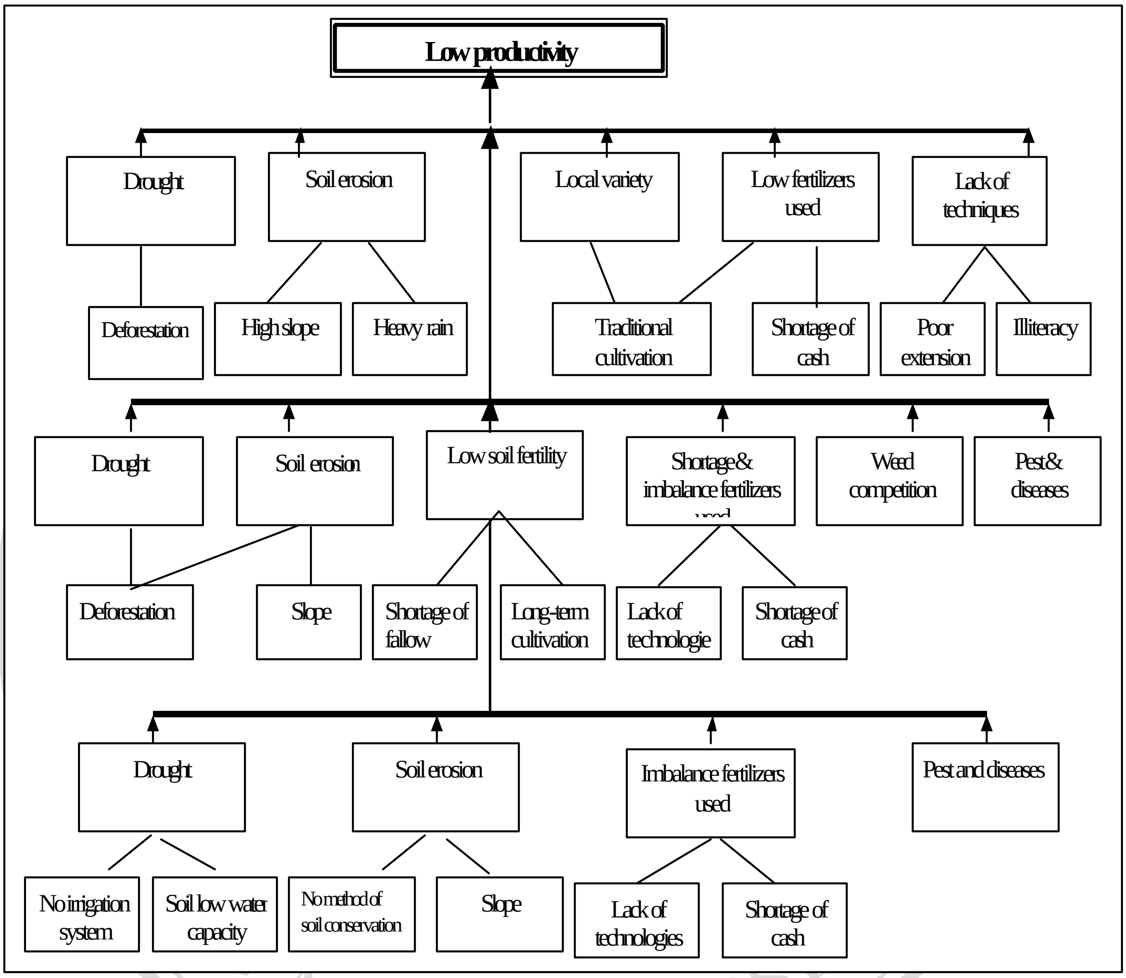


Figure 14 Causal diagram of constraints affected maize productivity
Source: Survey 2002. (Note: I = Slope land, II: midland and III: flat land area)

In the midland area, farmer determined the yielding constraints comprised of drought, soil erosion, low soil fertility, shortage and imbalance in fertilizer use, and weed competition and pest and diseases problem. Beside that, the secondary constraints also found for the midland area consisted of deforestation, slope, shortages of fallow period, long-term cultivation, lack of cash source and technologies.

In the flatland area, the yielding constraints were less than as compare with the steepland and midland area. There were four primary constraints found out consisted of drought, soil erosion, and imbalance fertilizer use and pest and diseases problem and the secondary constraints, which affected the primary constraints for this area included no irrigation system, low water capacity in the soil, without soil conservation methods, slope, and lack of cash and technologies.

As so far, the picture of constraint factors affect the maize production and maize productivity was build up that could help both local peoples and outsiders have in mind on the interactions of yielding constraints in maize production system in the rainfed area of Son La province. However, in order to make useful suggestions and determine the key problems for improving maize system in the future, it is essential to come up with setting priority and quantifying the effect of it. These issues will be solved in the next parts of this chapter.

5.2.2 Prioritizing the constraints

The pair-wise matrix and theory of Analytical Hierarchy Process (AHP) (Saaty, 1980) were used in constraint prioritization. The purpose of this is to compare the effective level of yielding constraint to maize productivity. In the progress, farmers were required to evaluate the relative importance of each constraint factor. The relative importance of each constraint factor was defined base on the comparison of level effectiveness of each yielding constraint to maize yield by score through farmer group discussion in PRA workshop. The weight value of each yielding constraint was calculated and then, the relative important of individual yielding constraint was defined in each land type.

5.2.2.1 Prioritizing constraints to maize productivity in the steepland area

In the steepland area, the result of farmer group discussion found out five constraint factors that directly affected maize productivity. In prioritization, farmers require to discuses among groups and then, defining the score for each constraint factor in matrix base on the comparison of the level effect between them. After the score of each yielding constraint was defined, the weight value for each constraint was calculated. The value of weight has determined the relative important of constraint (Table 18), this result accepted with the CR= 0.08 (Saaty., 1980).

Table 18. Prioritize the constraints to maize productivity in the steepland area

Items	Drought	Soil erosion	Old varieties	Low fertilizer used	Farmers' lack of techniques	Weig hts
Drought	1					0.27
Soil erosion	4/3	1				0.35
Old varieties	1/3	2/7	1			0.14
Low fertilizers use	1/2	1/3	1/3	1		0.13
Farmers' lack of techniques	1/3	2/7	2	1/3	1	0.11

Source: Farmer discussion 2002, (l = 5.39, CI = 0.096, CR= 0.08).

The result of prioritizing constraints for the steepland area showed that among constraints affected maize productivity, farmers more concerned about environmental stresses, such as soil erosion and drought with weight values 0.35 and 0.27, respectively. The old varieties and low fertilizer were assigned with the weight value 0.14 and 0.13. The lowest value was assigned for farmers' lack of techniques of 0.11. Thus, the order of yielding constraint in the steppland area as follow: soil erosion, drought, low fertilizer use and lack of technology, in which soil erosion, drought and low fertilizer use were considered as major yielding constraints in the steepland area.

5.2.2.2 Prioritizing constraints to maize productivity in the midland area

Differing from the steepland area, in the midland, after discussion farmers found out six yielding constraints involved in maize production, which consisted of soil erosion, drought, low soil fertility, shortage and imbalance in fertilizer use for maize, weed competition and pests and diseases attacking.

Farmer group discussion also was carried out to define the score for each yielding constraint base on the comparison of affected level of each yielding constraint to maize productivity. And then, the weight value for each yielding constraint was calculated with CR = 0.01 and then the relative important of each yielding constraint was determined (Table 19).

Table 19. Prioritize the constraints to maize productivity in the midland area

Items	Drought	Soil erosion	Low soil fertility	Shortage & imba-of fertilizer	Weed competition	Pests& diseases	Weight
Drought	1						0.22
Soil erosion	5/4	1					0.29
Low soil fertility	4/5	1/2	1				0.16
Shortage & imba-of fertilizer	2/3	4/7	4/5	1			0.14
Weed competition	1/3	1/5	2/3	2/3	1		0.07
Pests& diseases	2/5	1/3	4/7	4/5	4	1	0.12

Source: Farmerdiscussion, 2002. (l =6.06; CI= 0.0124; CR= 0.01).

The weight values among six yielding constraints (Table 19) showed that in the midland area, the drought and soil erosion also were major problems so that the weight values for them were assigned with values 0.22 and 0.29, respectively. The second, the low soil fertility, shortage and imbalance in fertilizer use and pests and diseases attack, which corresponding with weight values were 0.16, 0.14 and 0.12, respectively and the lowest weight value was assigned for weed competition 0.07. Thus, in midland area, the order of yielding constraint affect the maize yield follow by soil erosion, drought, low soil fertility, shortage and imbalance in fertilizer use, pest and diseases and weed competition, of which, four constraints namely are soil erosion, drought, low soil fertility and shortage and imbalance in fertilizer use were considered as major constraints in the midland area

5.2.2.3 Prioritizing constraints to maize productivity in the flatland area

Prioritizing the constraints to maize productivity on the flatland area was conducted as the same procedure in the steepland and midland area. Farmers discussed and compared the effective level of each yielding constraint to maize productivity. After the scores were filled up in the matrix, the weight value for each constraint was calculated with CR =0.08 (Table 20).

Unlike in steep land and midland, the result (Table 20) showed that the big problems in this area were drought stress, shortage and imbalance in fertilizer used for maize so the weight values were assigned 0.48 and 0.27, respectively. The soil erosion wasn't importance in maize yield reduction at the flatland the weight of soil erosion was assigned only 0.18 because soil erosion did occur widely in this area so that it hadn't affected the maize yield as in the steep land and midland area, and the lowest weight value was 0.07 belonged to pests and diseases problem.

Table 20 Prioritize the constraints to maize productivity in the flatland area

Items	Drought	Soil erosion	Imbalance fertilizer use	Pests& diseases	Weights
Drought	1				0.48
Soil erosion	1/2	1			0.18
Imbalance fertilizer use	1/4	2	1		0.27
Pests& diseases	1/5	1/3	1/6	1	0.07

Source: Farmer discussion, 2002.(l =4.11, CI= 0.036; CR= 0.04)

In summery, prioritizing constraints has showed the relative importance of yielding constraint affected the maize yield in Son La as follow were: drought, soil erosion, old varieties, low soil fertility, shortage and imbalance fertilizers used, damage of pest and disease, weed competition and farmers' lack of technologies.

These yielding constraints often appear at the maize field in growing season and simultaneously affected maize productivity in the upland area.

5.3 Constraints and quantitative assessment

The yield gap analysis, causal diagram and prioritization only identified the yielding constraints and defined the order of each constraint affected the maize productivity through farmer group discussion and AHP. However, it could not quantify the volume of yield loss due to these constraints, this is the main reason why the quantitative assessment model was adopted in this study.

5.3.1 Descriptive statistics of the variables

The variables in model comprised of the quantitative variables are inputs used in maize production in the whole area, such as nitrogen, phosphorous and potassium and the qualitative variables are yielding constraints, which were defined in interviewing process. In this part, only quantitative variables were described (Table 21).

Table 21 Descriptive statistics of the variables included in model for maize production

Variables	Nitrogen (kg/ha)	Phosphorous (kg/ha)	Potassium (kg/ha)
Mean	83.7	42.4	48.8
Std. Dev	40.7	26.9	34.8
CV (%)	48.6	63.4	71.4
Max	149.1	95.0	97.2
Min	37.3	33.3	24.3

Source: Survey, 2002.

Table 21 showed that average input used for maize was quite low as follow: nitrogen was 83.7 kg per hectare, phosphorous was 42.4 kg per hectare and potassium was 48.8 kg per hectare. The variation of inputs used among farmer households in whole area, as nitrogen was 48.6 percent, phosphorous was 63.4 percent and potassium was 71.4 percent. The gap of inputs level among farmers household was quite high for nitrogen from 37.3 to 149.1 kg per hectare, phosphorous from 33.3 to 95.0 kg per hectare and potassium from 24.3 to 97.2 kg per hectare.

5.3.2 Estimate production function

The fundamental of quantitative assessment in this study was based on the regression model (Cobb-Douglas production function) with its purpose to measure the effect of inputs and yield constraints on maize yield. The explanatory variables consisted of nitrogen (urea 46 percent), phosphorous (Super phosphate 17.6 percent) and potassium (potassium sulfate 60 percent) and dummy variables included the yielding constraints which were identified before, except the effect of drought, which could not be used in the model because the data used in this study was one year data set (not time series data).

The Ordinary Least Square (OLS) method was employed in this study to estimate the coefficients of production function. Before estimating, in order to ensure the Classical assumptions for OLS estimator, the multicollinearity and heteroskedasticity had checked through correlation matrix and Breusch-Pagan test to avoid the violations. The result in Appendix Table 21 and the Breusch-Pagan test have suggested of the absence of multicollinearity and heteroskedasticity associated in the model. Finally, the coefficients of production function are presented in Table 22.

Table 22 Coefficients of variables result from production function for maize

Variables	Coefficients	Standard Error	t-statistics
Intercept	8.156602***	0.0583	139.7911
Ln X_1	0.079135***	0.0130	6.0532
Ln X_2	0.01296ns	0.0166	0.7778
Ln X_3	0.034322***	0.0132	2.5857
D1	-0.27928***	0.0293	-9.5003
D2	-0.22886***	0.0341	-6.7051
D3	-0.28656***	0.0368	-7.7796
D4	-0.08414**	0.0356	-2.3577
D5	-0.05876**	0.0286	-2.0486
D6	-0.02313ns	0.0306	-0.7558
R^2	0.86		
$F_{0.01\ (9,\ 166)}$	1.64		
F computed	115.42, Reject $H_0 = \beta_1 = \beta 2 = \beta_3 = 0$		
No of observation	176		
Standard Error	0.176		

Note: ***, ** and ns refer to significant at the one percent, five percent and ten percent level and non-significant, respectively.
Variety Dummy: D1 = 1 if variety is not hybrid variety, and 0 if otherwise

Soil Dummy: D2 = 1 if land have low fertility, and 0 if otherwise

Erosion Dummy: D3 = 1 if erosion occurs and affected yield in the farm, and 0 if otherwise

Pest Dummy: D4 = 1 if pest & diseases damage and affected yield, and 0 if otherwise

Weed Dummy: D5 = 1 if weed affected yield, and 0 if otherwise

Lack of technology: D6 = 1 if farmer household said lack of technology, and 0 if otherwise

The estimated result of production function for the whole area was conducted. The results (Table 22) showed that the coefficients of fertilizer variables, such as nitrogen, phosphorous and potassium have positive values namely $\beta_1 = 0.079$, $\beta 2 = 0.0129$ and $\beta 3 = 0.0343$, respectively. These imply that the maize yield could increase continuously if maize growers add more fertilizer. In other words, the fertilizers used in farmer practice did not reach the optimum level. It is, however, the coefficient of phosphorous was non-significant positive value in terms of statistic. It means that the maize yield is hard to increase significantly if maize growers keep increase in the quantity of phosphorous. Therefore, in order to increase maize yield, maize growers should invest more in nitrogen and potassium appropriately. If maize growers increase the inputs up 1 percent of nitrogen, the output could increase 0.079 percent, holding other inputs and factors are constant. Similarly, maize growers increase the inputs 1 percent of potassium, the maize yield could increase 0.034 percent, holding other inputs and factors are constant. With phosphorous, the maize yield would unremarkably increased when added more phosphorous.

The coefficient of dummy variable of old varieties had negative value γ_1=-0.279 and was significant in terms of statistical at one percent level. It means that if old varieties use in production, the maize yield in that farm will decline. Therefore, in order to increase maize yield, farmers should pay more attention to replacing old varieties by hybrid varieties.

The coefficient of low soil fertility variable, dummy variable had negative value γ_2=-0.228 and was significant in terms of statistical at one percent. It noted that if maize grew in the farms with low soil fertility, the yield obtained would be lower than at the farms have good soil fertility.

The coefficients of dummy variables for soil erosion, pest and disease damage and weed competition were found negative values, which were γ_3= -0.286, γ_4=-0.084 and γ_5=-0.058, respectively and were significant in terms of statistical. It implies that if these constraints occurred on the farmers' farm, which would affect the maize yield and yield loss was unavoidable.

The coefficient of dummy variable of farmers' lack of technique had negative value γ_6= -0.023 and was non significant in terms of statistic so that the effect of farmers' lack of technologies to maize yield was unremarkable in this area. It noted that although farmer households could not contact with extension staffs, the maize yield obtained at their farms was not different from farmers who directly contacted with extension staffs. It could be explained that the farmer-to-farmer network in the villages has been successful in terms of transferring technology.

The R^2 of the regression model was 0.8622, which implies that 86.22 percent of the total variation of maize yield could be explained by variables in the model. The rest of 13.78 percent of maize yield has contributed by other factors or the variables outside of the model. Moreover, the standard error of the model was ų= 0.176, which implies that the degree of fitness of the model was quite high with data set, which were collected in the study site.

5.3.3 Estimate yield gap due to yielding constraints

Estimating the potential yield loss is often quite difficult and easy to be misleading. The best way, we can determine the yield losses from events, such as environmental stresses or poor productive performance events by picking data in the plots from the affected and not affected areas by events and then, the yield gap was defined by comparison of the yield obtain between these farms. In this study, the average yield gap was computed base on the comparison of the average yield obtained at the site and the actual yield obtained from farms which were affected by constraints.

The fundamental for estimation of the yield gap was based on the original regression model (Cobb-Douglas production function) Yield = $\alpha X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} e^{\Sigma \gamma i Di}$ (i =1…6). The average inputs use, such as nitrogen, phosphorous and potassium combine with the appearance of individual yielding constraint at the farm were used in computation. The percentage of yield gap of each constraint was presented in Table 23.

The results (Table 23) showed that the average of maize yield obtained in a farm used with average amount of chemical fertilizers: 83.86 kg of nitrogen, 42.43 kg of phosphorous and 49.4 kg of potassium and without any other yielding constraints involved in that farm. Consequence, the maize yield could obtain about 5884.0 kg per hectare.

Table 23 The model estimate contribution of constraints to yield gap

Varia	Coeff	Avera	If constraint occur					
		Input	D_1	D_2	D_3	D_4	D_5	D_6
a	8.156602							
LnX_1	0.079135	83.86						
LnX_2	0.01296	42.49						
LnX_3	0.034322	49.40						
D_1	-0.27928	0	1	0	0	0	0	0
D_2	-0.22886	0	0	1	0	0	0	0
D_3	-0.28656	0	0	0	1	0	0	0
D_4	-0.08414	0	0	0	0	1	0	0
D_5	-0.05876	0	0	0	0	0	1	0
D_6	-0.02313	0	0	0	0	0	0	1
Yield obtain (kg/ha)		5884.0	4451.8	4680.1	4413.0	5407.4	5548.0	5748.7
Percent reduction		0.0	23.6	20.4	25.0	8.1	5.7	2.3
Yield = $\alpha X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} e^{\Sigma \gamma i D i}$ (i =1…6)								

The amount of yield gap due to non-optimum rate of fertilizer application can be calculated for each farmer household base on the amount of fertilizer application, which was applied by individual maize grower, holding the other variables constant and the coefficients of regression model.

The yield gap due to non-optimum rate of fertilizer application for the whole area was calculated between the lowest inputs used and the highest inputs used. For example, with a farm, farmer used lowest inputs in the data set: nitrogen was 37.3 kg per hectare, phosphorous was 33.3 kg per hectare and potassium was 24.3 kg per hectare and without any constraints involved in growing season, the maize yield could obtain about 5380.3 kg per hectare. Similarity conditions, if farmer uses with highest inputs use: nitrogen was 149.1 kg per hectare, phosphorous was 95.0 kg per hectare and potassium was 97.2 kg per hectare, the maize yield could obtain 6423.8 kg per hectare. Accounting for the yield gap occurs between lowest and highest inputs used at the maize field without any yielding constraint. The yield gap was 1043.6 kg per hectare, which equals to 16.2 percent of yield was increased thank to add more fertilizers as compare with lowest inputs used. Of which nitrogen contributed about 11.2 percent and contribution of potassium was 4.8 percent of yield increases. Moreover, the yield gap due to shortage of fertilizer used in the individual farmer households could be calculated base on the coefficient of regression model and individual input level similar the above procedure.

For the other yielding constraints, the yield gap was computed base on the comparison of the average yield obtained (Table 23) and the yield at the farm having constraint involved. If farmer used old varieties, the yield only obtained about 4451.8 kg per hectare and the average percent of maize yield gap due to old varieties was 23.6 percent of total yield as compare with the farms that used the hybrid varieties. The effect of low soil fertility that made average yield reduction was about 20.4 percent of total yield as compare with the good soil farm and the rest of yield could obtain 4680.1 kg per hectare. The highest of yield loss under soil erosion stress was 25.0 percent compare with the unaffected farms, and the rest of yield could obtain about 4413.0 kg per hectare. Under pest and diseases attack that made yield loss about 8.1 percent, weed was 5.7 percent and lack of techniques was 2.3 percent of total maize yield reduction and the maize yield for each could obtain about 5407.4 kg per hectare, 5548.0 kg per hectare and 5748.7 kg per hectare, respectively.

In short, evaluation of the yield loss due to yielding constraints, model indicated that the order of yield constraints were soil erosion was 25.0 percent and follow by old varieties was 23.6 percent, low soil fertility was 20.4 percent, shortage of fertilizer use varied from 0 - 16.2 percent, and pest and disease was 8.1 percent. Weed problem and farmers' lack of techniques reduced the maize yield about 5.7 percent and 2.3 percent, respectively. Thus, the estimated results from quantitative assessment on the yield loss because of yielding constraints seem suitable with the results of farmer prioritization the yielding constraints to maize productivity in PRA workshop.

The yield loss due to drought could not be estimated in the regression model that considered as a limitation of this study, because when drought occurs, it often affect the growth rate of maize in the whole area. So in order to evaluate the effect of drought, the time series data need to be collected. In that case, model will point out the effect of drought to maize yield. However, in PRA workshop, information of farmers have confirmed that the yield loss due to drought ranged from 25 to 40 percent of total yield as compare with the year having the good rain condition. The level of yield loss depends on the degree of drought stress and the growth stage of maize; the heavy yield loss would be happened if drought occurred within flowering stage.