# CHAPTER 4

# RESULTS AND DISCUSSIONS

## 4.1 Upland rice based cropping systems in Luang Prabang province

In Xieng Ngeun district as well as in the country as a whole, shifting cultivation is practiced by all ethnic groups, Lao Loum (Lao of the lowland), Lao Theung (Lao of the mountain slopes), Lao Soung (Lao of the mountain summits), depending on location and topographic conditions. In the case of Xieng Ngeun district, however, Lao Soung and Lao Theung may be more dependent on upland agriculture.

Xieng Ngeun district has high proportion of upland rice area, which is practiced by about 4,500 households (over 80% of the total households). In 1998, rice was planted on a total area of 4,300 ha, of which 3700 ha (86%) was upland rice, which produced 6,200 tons, over 70% of the district's rice harvest (Figure 4.1).

### 4.1.1 Upland rice environment

Xieng Ngeun district is located at 19° 20' N latitude and 102° 00' longitude. The district occupies a total area of 185,600 ha, supports a population of 33,547 (Xieng Ngeun District Agricuiture Service, 1998).

#### *4.1.1.1 Climatic resources*

The climatic data for the Xieng Ngeun district is limited, but rainfall data are available. There are two distinctive seasons, dry and rainy. The rainy season starts from May to October. The annual rainfall generally is over 1,000 mm., of which more than 60% were recorded during May to August. Based on annual precipitation, Xieng Ngeun district was considered to be drier area compared to precipitation of the whole province (Figure 4.2). As a result, rainfall could be an important factor that limited crop growth, reducing crop yields. Successful weather forecasting combined with appropriate cropping practices could substantially reduce crop losses caused from drought.

#### *4.1.1.2 Landscape and soil resources*

Because of mountainous topography, land availability for lowland rice production is limited. Areas under permanent agriculture that are currently used for rice cultivation occupy only 0.1% of total land area (Table 4.1), while areas under potential forest, in which the crown density has been reduced to less than 20% because of logging and shifting cultivation, and areas on which upland rice and other non-rice crops are grown occupy over 70% of the total area (185,600 ha).

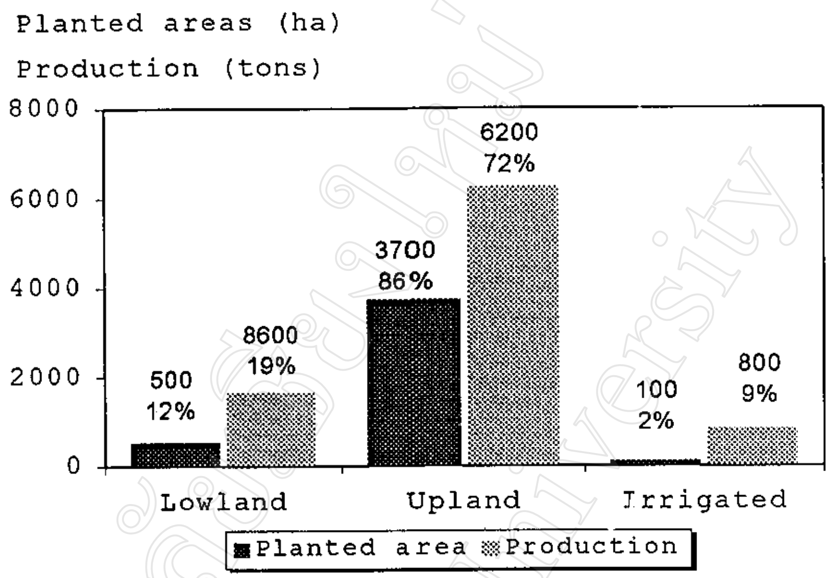



Figure 4.1 Rice production in Xieng Ngeun district, Luang Prabang province.

*(Source: Provincial Crops Section, 1998)*

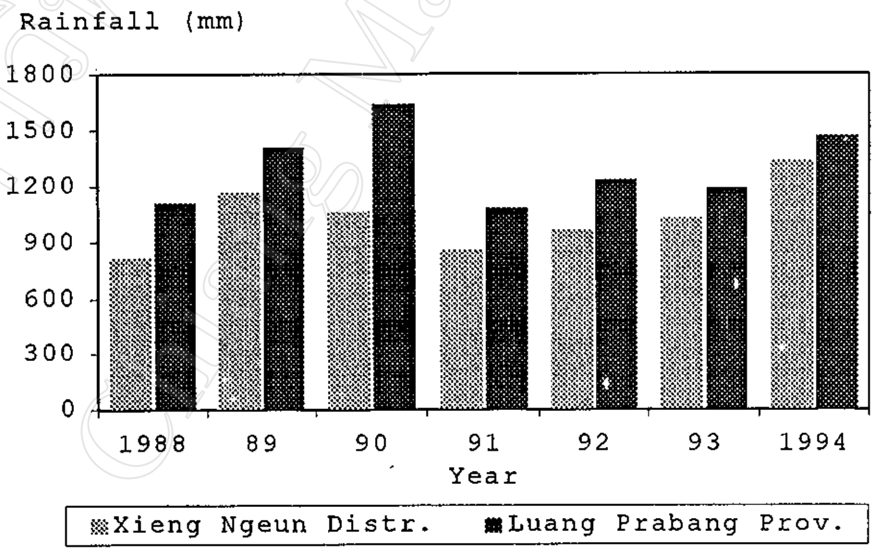



Figure 4.2 Annual rainfall for Xieng Ngeun district and Luang Prabang Province during 1988-1994.

*(Source: Provincial Agriculture Service of Luang Prabang 1997)*

Table 4.1 Land use and forest types of Xieng Ngeun district.

| Main groups | Land use and forest types | Area | |
|---|---|---|---|
| | | ha | % |
| Areas of current forest | Mixed deciduous forest | 38,169 | 20.6 |
| Areas of potential forest | Bamboo | 10,192 | 5.5 |
| | Unstocked forest | 119,774 | 64.5 |
| | Ray | 4,498 | 2.4 |
| Other wooded areas | Heathy, stunted, and scrub forest | 364 | 0.2 |
| Areas of permanent agriculture | Rice paddies | 231 | 0.1 |
| Other land use | Grass land | 12,372 | 6.7 |
| Total | | 185,600 | 100 |

*(Source: IBSRAM, 1996)*

Most areas that are used for agriculture are concentrated on sloping land. Over 90% of fields has a slop gradient exceeded 30% (Table 4.2). The predominant upland soils are classified as Typic Haplustults, and Kanhaphic Haplustults (IBSRAM, 1996). They are clay loam, fairy acidic, with low CEC (Taaka and Jo, 1994).

Nutrient concentration is greatest in the top 0–3 cm interval (Table 4.3). For most nutrients content decreases with soil depth. The concentration of available P in the 3-10 cm depth interval is only 23% of its concentration in the top 3 cm interval.

Table 4.2 Land distribution by slope classes in Xieng Ngeun district.

| Slope class (%) | Area | |
|---|---|---|
| | ha | % |
| 2 – 8 | 3,250 | 1.75 |
| 8 – 16 | 2,150 | 1.16 |
| 16 – 30 | 6,540 | 3.53 |
| 30 – 55 | 48,240 | 25.99 |
| >55 | 125,420 | 67.57 |
| Total | 185,600 | 100 |

*(Source: IBSRAM, 1996)*

Table 4.3. Selected soil chemical properties in Xieng Ngeun district (Average of 2 sites, 20 sub-samples)

| Parameters | Depth (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-3 | 3-10 | 10-25 | 25-50 | 50-75 | 75-100 |
| pH | 5.78 | 4.89 | 4.61 | 4.75 | 4.87 | 5.00 |
| Total N (g kg soil$^{-1}$) | 2.77 | 2.29 | 1.97 | 1.84 | 1.74 | 1.60 |
| OM (g kg soil$^{-1}$) | 56.65 | 36.10 | 24.35 | 18.2 | 14.35 | 11.55 |
| Total P (mg kg soil$^{-1}$) | 751.50 | 589.00 | 514.5 | 465.00 | 429.00 | 428.00 |
| Avail. P (mg kg soil$^{-1}$) | 37.90 | 8.70 | 6.55 | 5.25 | 6.00 | 6.10 |
| Avail. K (mg kg soil$^{-1}$) | 402.00 | 152.50 | 84.00 | 58.5 | 50.00 | 44.50 |

*(Source: Roder et al., 1991)*

### 4.1.2 Socio-economic resources

Xieng Ngeun district had a total population of 33,547 (5,579 families). About 3,906 families (70%) were upland farmers, while about 648 families (12%) were exclusively lowland farmers, about 388 families (7%) were engaged in both upland and lowland activities. About 637 families (11%) were supported through employment as government officials, businessmen, traders, workers, and others (Xieng Ngeun District Agriculture Service, 1998).

According to the household survey carried out in April 1998, average family size in Xieng Ngeun district, from a sample size of 50 households, was 7 people. Considering the population distribution by age, the population of the surveyed areas was characterized by high growth rate (Figure 4.3). Over 50% of the total population were under 16 years of age.

Upland rice production was totally dependent on natural environment. A good rain and fewer pest damage often resulted in better harvest and vice versa. As a result, local rice consumption in the upland areas varied from one year to another. In 1997, about 10% of the farmers interviewed had a rice surplus (Figure 4.4). Approximately 42% had rice sufficiency (<1 month of rice deficit is considered to be rice sufficient) and about 28% had rice deficit for 1 to 2 months. In 1998, the situation went much worse for the same group of farmers i.e. almost 80% had rice deficit for 3 months or longer.

Considering the percentage of farmers with rice surplus and rice deficit, the surveyed areas may be considered to be largely rice deficit areas. Rice must be imported into the villages each year. Still, most farmers reported that they still eat rice, when they faced with rice shortage. Farmers borrowed rice from friends or relatives, and/or bought from the market. Maize, cassava, or wild yams could substitute for rice, but only for a few days. Drought, pest, and too many weeds were the main reasons for rice shortage cited by farmers (Figure 4.5).

In 1997, the average cash income for households in the surveyed area was 482,000 Kip or about US$160 (exchange rate 3,000 kip/$). However, the income varied significantly among households (Figure 4.6). About 50% of the households had an annual income of less than 300,000 kip (<US$100). These income levels may be considered high if compared to the incomes of farmers who live in more remote villages with poor market accessibility. Livestock, agricultural, and forest products were the principal source of income for the surveyed farmers. Handicraft and wage earning were minor sources of their income (Figure 4.7).

### 4.1.3 Animal production

Animal husbandry was an another important economic activity, next to upland rice production, which provided both employment and income to the rural farmers. Animal raising also was an important component of the traditional upland rice farming systems in Laos. Animal products were the main source of both cash and protein. Most farmers in the area surveyed raised more pigs and poultry than other kinds of animals (Figure 4.8). The main purposes for raising animals was for cash savings and sales in the case of emergencies, home consumption, and religious rituals. Although livestock could bring in desirable income because of high market demand, there were some constraints to raising more animals depending on the type of animals. For cattle the main constraints were limitation of grazing area, diseases and management, while the main constraints to pigs and poultry were diseases, fodder shortage, and shortage of capital (Figure 4.9).

The main source of forages for cattle is natural fallow vegetation, while the feed for poultry and pigs are rice bran, broken rice, maize, and vegetables which are collected from rice fields or fallow lands.

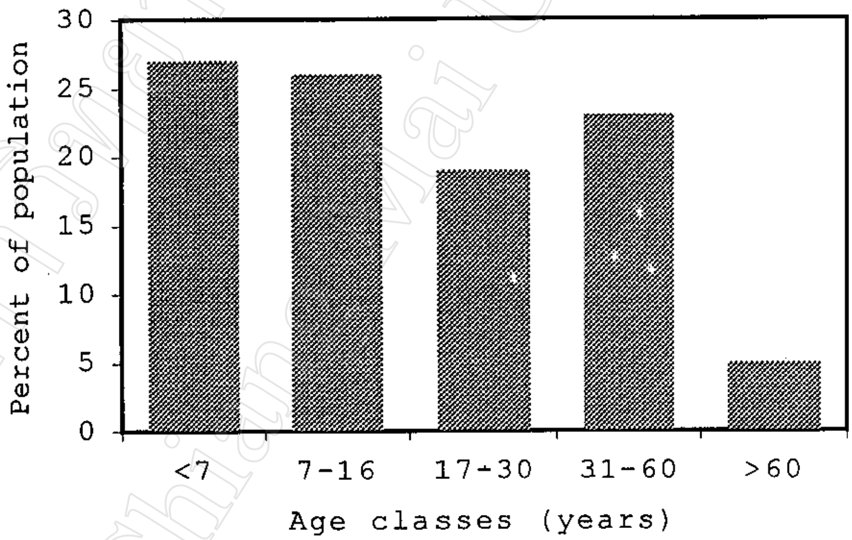



Figure 4.3 Population distribution by age in Xieng Ngeun district (N=50).

*(Source: Household Survey, 1998)*

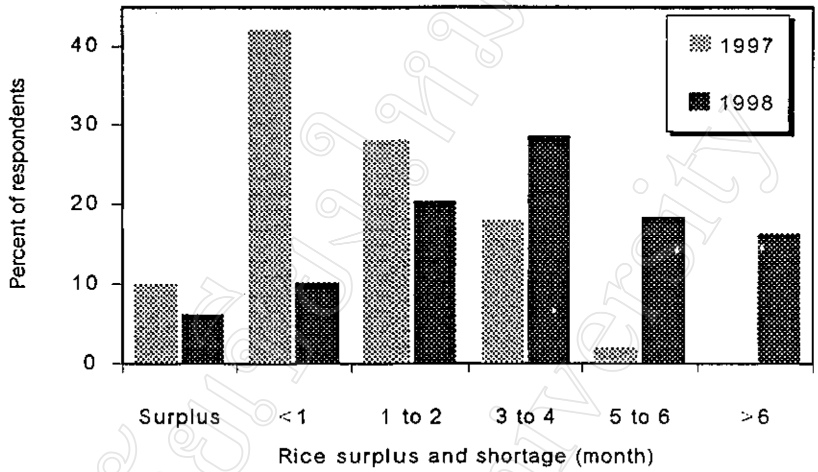



Figure 4.4 Rice consumption in Xieng Ngeun district in 1997 and 1998 (N=50).

*(Source: Household Survey, 1998)*

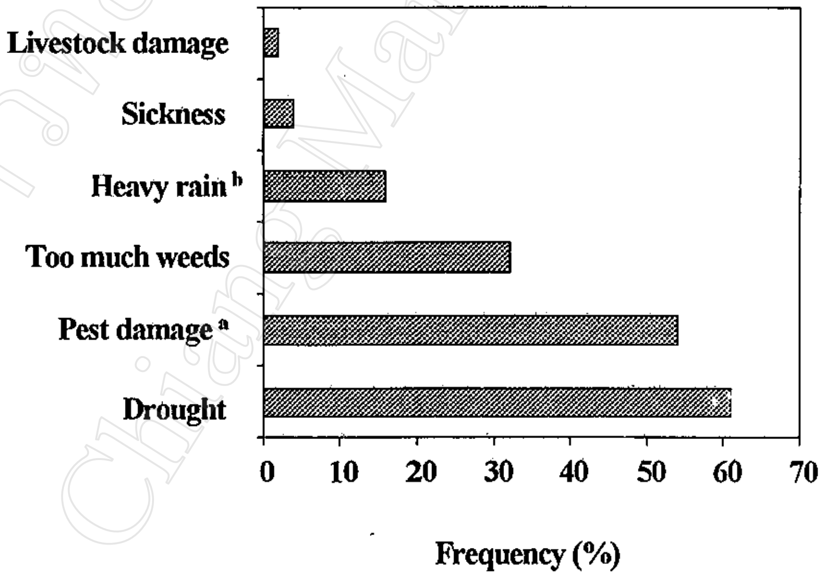



Figure 4.5 The main reasons for rice deficiency (N=50).

[a] Rats, birds, stem borers, white grubs, rice bugs and grasshoppers.

[b] Mostly after rice planting.

*(Source: Household Survey, 1998)*

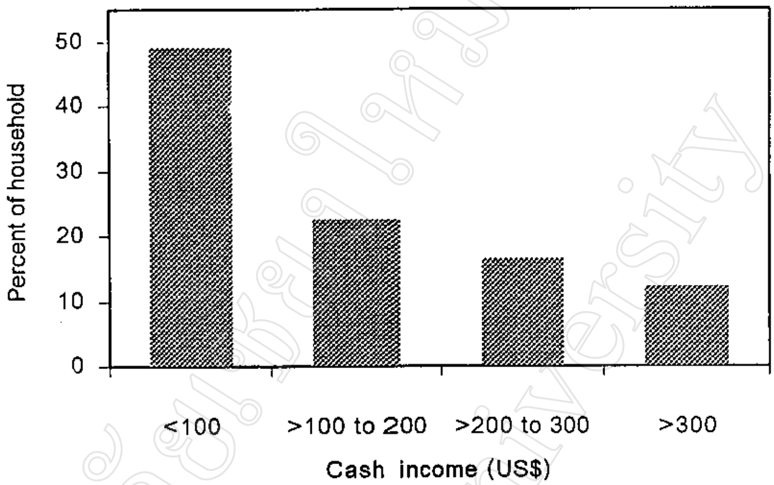



Figure 4.6 Income distribution of upland households in Xieng Ngeun district.

*(Source: Household Survey, 1998)*

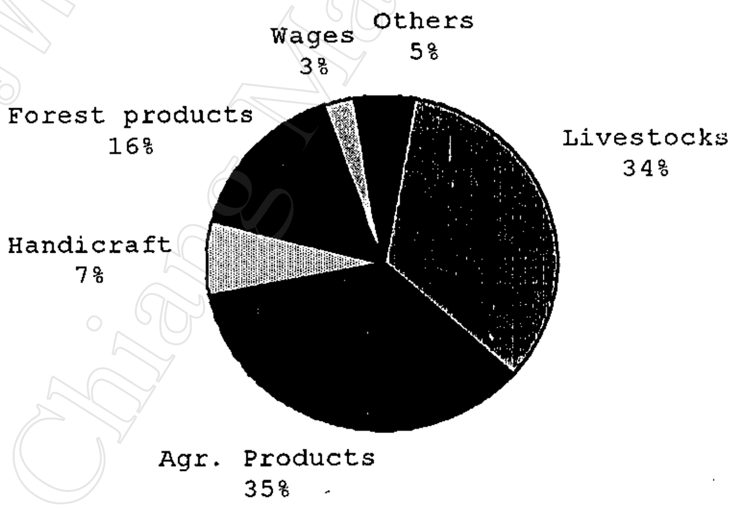



Figure 4.7 Source of cash income of upland households in Xieng Ngeun district.

*(Source: Household Survey, 1998)*

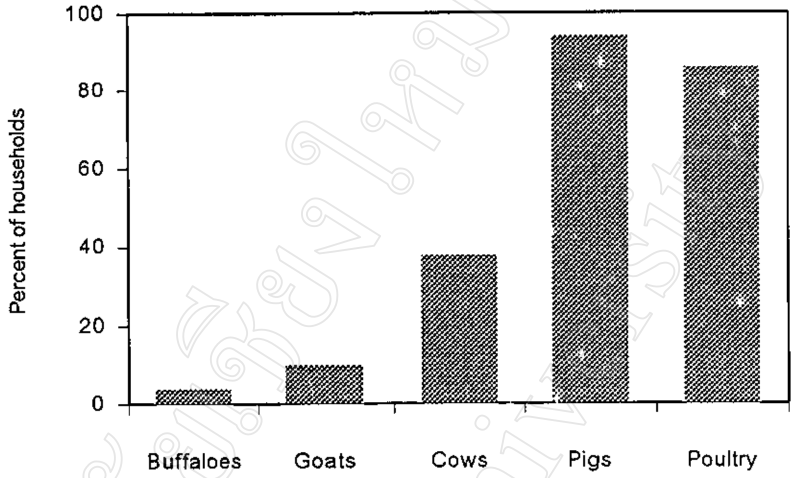



Figure 4.8 Animals commonly raised by farmers in Xieng Ngeun district.

(N=50). *(Source: Household Survey, 1998)*

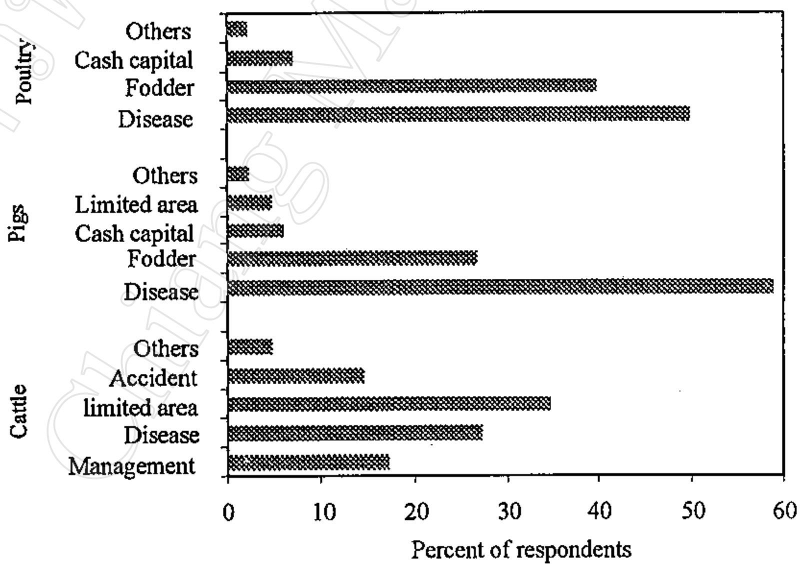



Figure 4.9 Reasons cited by farmers for not raising more animals (N=50)

*(Source: Household Survey, 1998)*

### 4.1.4 Upland rice production practices

Shifting cultivation, with upland rice as the main crop, is the predominant land use in the villages surveyed. The practice consists of cutting the vegetation (trees, shrubs) during the dry season (January, February), allowing it to dry and burning shortly before the onset of the rainy season. Seeds are dibbled in May or early June.

Upland rice is rarely monocropped. A range of non-rice crops are usually planted with upland rice through mixed cropping, intercropping, and/or relay cropping (Figure 4.10), mainly for home consumption, sometimes for sale. The non-rice crops are also grown where rice cannot be planted, such as on termite mounds, or in places that are difficult to access (too steep or rocky places), or where there may be less competition with rice crop (along paths or borders of the fields, near tree stumps). Some crops such as cucumber, water melons, and melons, are usually mixed and dibbled with rice seeds. Up to 25 species were reported by the farmers in the surveyed area. Most of them planted about 4 to 10 non-rice crop species.

The main inputs for the upland rice come from internal sources. Family labor is the most important input. To produce one ha of upland rice requires about 300 man day$^{-1}$ (Roder, et al., 1994). No organic or inorganic fertilizers were presently used. Soil fertility is replenished by fallowing the land. Subsequent crops use nutrients contained in the ash from burning and/or from decomposition processes.

The average farm size for upland rice production in the area was 3.3 ha per household, while the average area planted to rice was 1.0 ha per household. The fallow periods of 2-3 years could not be sufficient to restore soil fertility for favorable growth and development of subsequent rice crops, compared with traditional systems which fallow periods lasted as long as 20 years or more.

Weeds remain the major constraint to upland rice production, requiring 3 to 5 hand weedings per year and consuming over 50% of total labor inputs of 300 man $day^{-1}$ $ha^{-1}$ (Roder et al., 1994). Weed had become even more important in recent years. Almost farmers in the surveyed areas reported that they had weeded their rice field up to six times during the rice season. Therefore, Lao upland farmers presently are forced to change to another cultivation practices that are more efficient and optimize returns to labor.

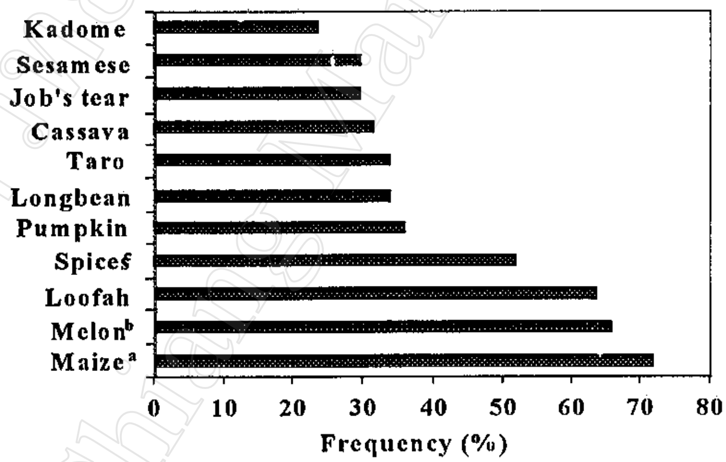



Figure 4.10 Upland crops often grown together with upland rice.

[a] Mostly sweet varieties for human consumption.

[b] Cucumbers, melons, and water-melon.

[c] Lemon grass, onion, chillis, and some other spices necessary for cooking.

*(Source: Household Survey, 1998)*

## 4.2 Agronomic performance of rice/pigeon pea intercropping

### 4.2.1 Effects of intercropping on the growth of rice and pigeon pea

#### *4.2.1.1 Rice*

Above ground biomass of rice was measured three times during the growing season 93 days after sowing (DAS), 110 DAS, and at harvesting time(145 DAS). Rice biomass (g $m^{-2}$) was calculated based on the area of the respective sole crop (25x25cm) for rice in order to be able to compare the differences in growth performance among treatments tested. Unfortunately, efforts to quantify crop growth rate (g $m^{-2}$ $day^{-1}$) under different treatments were not reliable because of the uneven growth of the rice crop that caused high variability within treatments. The variation ranged from 6 to 121%, with most ranging from 35 to 63% (Table 4.4). Late rice replanting (about one month after pigeon pea was planted), poor crop establishment due to low seed germination, may partly be the cause of uneven growth of the rice crops. The experimental variation increases over time. This may have been caused by the effect of the treatments tested.

Nevertheless, some general conclusion can be made among treatments tested can be made. Figure 4.11 illustrates rice growth performance under different treatments tested. In Treatment 1 (Sole rice cropping) rice grows better (probably with decreasing rate) than strip and row intercropping. Row intercropping treatments were seriously affected by pigeon pea, comparing with strip intercropping. Treatment 6 and 8 were the most serious affected. The reduction in biomass accumulation of rice in intercropping treatments could be mainly affected by the shading of pigeon pea. After about one month rice in these treatments had already been observed to perform badly. Stem growth was weak and plant started to fall over. The highest growth was observed for Treatment 1 (sole rice crop). Treatment 1 was observed to perform better than all of the intercropping treatments.

### *4.2.1.2 Pigeon pea*

Above ground biomass (g $m^{-2}$) was also calculated based on the area of sole crop, 25x 75cm. The variation of the data observed was generally lower than that of the rice crop (Table 4.5). The variation ranged from 11 to 64 %. Treatment 7 was observed to grow better than the other treatments (Figure 4.12). This indicated that the planting distance of 25x75 cm were not favorable for the growth of pigeon pea.

Table 4.4 Rice sample variability.

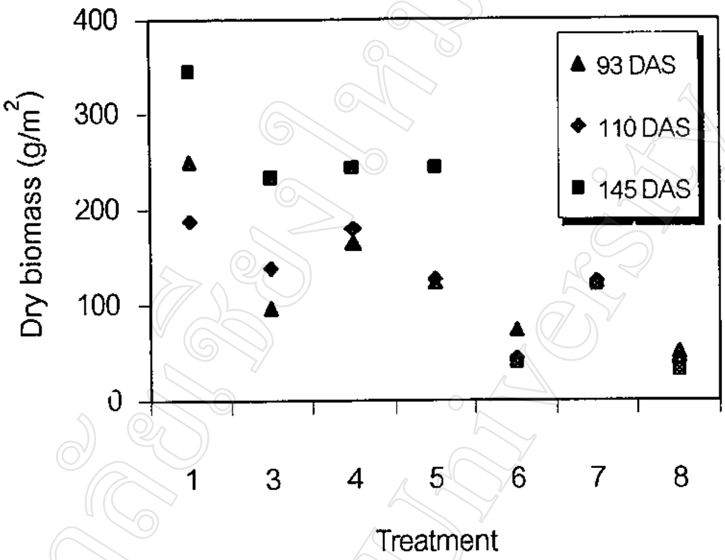
| Treatments | (Dry biomass at 93 DAS )[a] | | | Dry biomass at 110 DAS | | | Dry biomass at 145 DAS | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean ($g/m^2$) | Range | CV (%) | Mean ($g/m^2$) | Range | CV (%) | Mean ($g/m^2$) | Range | CV (%) |
| 1. Sole rice (RI100%) | 249.9 | 200.4 | 33.1 | 186.8 | 156.4 | 39.7 | 276.0 | 240.5 | 38.8 |
| 3. 50%RI:50%PP strip cropping | 96.0 | 64.0 | 31.4 | 137.1 | 100.4 | 38.0 | 152.6 | 327.7 | 101.1 |
| 4. 75%RI:25%PP strip cropping | 164.0 | 21.3 | 6.7 | 178.6 | 96.5 | 24.9 | 204.1 | 265.9 | 60.9 |
| 5. 25%RI:75%PP strip cropping | 123.0 | 144.0 | 53.1 | 126.0 | 104.3 | 34.5 | 158.1 | 273.6 | 72.7 |
| 6. 50%RI:50%PP row intercropping | 73.3 | 69.3 | 45.4 | 43.4 | 38.6 | 40.7 | 159.7 | 195.9 | 52.5 |
| 7. 75%RI:25%PP row intercropping | 124.0 | 64.0 | 25.2 | 123.6 | 88.8 | 30.1 | 192.5 | 241.6 | 57.8 |
| 8. 25%RI:75%PP row intercropping | 51.0 | 36 | 29.6 | 40.5 | 52.1 | 60.6 | 92.1 | 241.1 | 121.0 |
| Whole experiment | 125.9 | 324.0 | 58.8 | 119.4 | 278.0 | 56.9 | 176.4 | 419.3 | 65.9 |

[a] average from 4 replicates

Table 4.5 Pigeon pea sample variability.

| Treatment | (Dry biomass at 93 DAS)[a] | | | Dry biomass at 110 DAS | | | Dry biomass at 145 DAS | | | Dry biomass at 295 DAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean ($g/m^2$) | Range | CV (%) | Mean ($g/m^2$) | Range | CV (%) | Mean ($g/m^2$) | Range | CV (%) | Mean ($g/m^2$) | Range | CV (%) |
| 2. Sole pigeon pea (PP100%) | 237.0 | 300.9 | 52.0 | 299.6 | 102.6 | 15.9 | 571.6 | 784.0 | 60.6 | 234.3 | 200.6 | 43.8 |
| 3. 50%RI:50%PP strip cropping | 243.8 | 65.8 | 11.9 | 306.1 | 381.8 | 57.7 | 463.0 | 156.8 | 14.1 | 260.0 | 345.9 | 58.9 |
| 4. 75%RI:25%PP strip cropping | 234.8 | 226.4 | 41.5 | 312.3 | 306.9 | 44.3 | 597.8 | 545.1 | 38.4 | 400.5 | 314.2 | 41.3 |
| 5. 25%RI:75%PP strip cropping | 302.9 | 129.4 | 18.0 | 263.7 | 297.8 | 49.2 | 529.5 | 204.1 | 15.9 | 326.9 | 121.9 | 16.9 |
| 6. 50%RI:50%PP row intercropping | 369.1 | 308.0 | 38.2 | 534.6 | 296.0 | 22.7 | 647.7 | 492.8 | 37.1 | 404.6 | 140.1 | 16.5 |
| 7. 75%RI:25%PP row intercropping | 346.6 | 519.5 | 64.3 | 817.8 | 827.5 | 46.9 | 966.0 | 283.7 | 13.8 | 542.5 | 263.7 | 22.9 |
| 8. 25%RI:75%PP row intercropping | 229.7 | 204.1 | 40.8 | 321.3 | 225.5 | 29.0 | 569.3 | 403.2 | 31.5 | 308.1 | 180.8 | 28.4 |
| Whole experiment | 280.6 | 583.7 | 43.6 | 407.9 | 919.9 | 61.4 | 620.7 | 784.0 | 38.1 | 353.4 | 565.3 | 40.1 |

[a] average from 4 replicates




Figue 4.11 Biomass accumulation of rice under treatments tested.

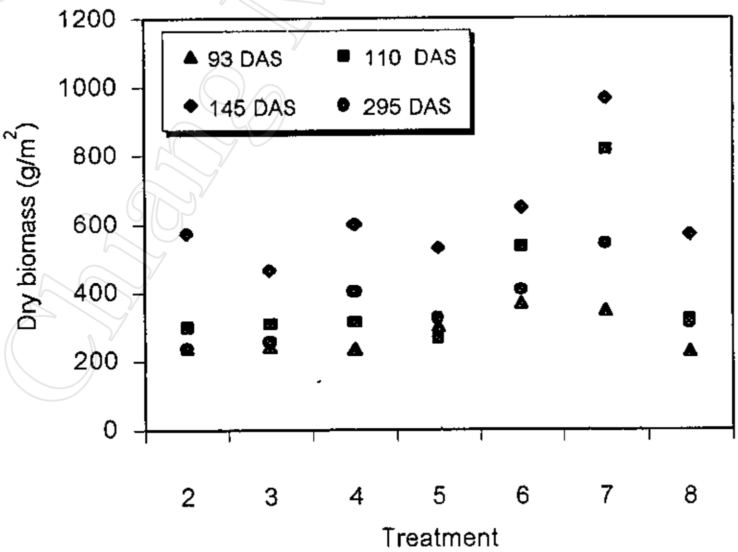



Figure 4.12 Biomass accumulation of pigeon pea under treatments tested

### 4.2.2 Effects of intercropping on biomass production and yield of rice and pigeon pea

Both biomass production and yield of rice and pigeon pea were calculated based on the area that a particular crop occupied under different treatments. The area of one hill of rice was 25x25 cm, 25x50 cm, 25x32.5 cm, and 25x100 cm for Treatment 1, 3 and 6, 4 and 7, and 5 and 8, respectively. The area of one hill of pigeon pea was 25x75 cm, 25x150 cm, 25x325 cm, and 25x100 cm for Treatment 1, 3 and 6, 4 and 7, and 5 and 8, respectively.

Analysis of Variance results of rice yield and biomass production show highly significant difference ($P < 0.01$) among the treatments tested (Table 4.6). In sole rice (Treatment 1) the rice yield was 1,212 kg $ha^{-1}$. Intercropping pigeon pea into rice reduced rice yield as well as biomass production. Rice yield reduced 84%, and 100% by strip cropping, and row intercropping, respectively. Dry biomass was also reduced 93%, and 96% by strip and row intercropping, respectively. Late replanting of rice probably increased poor competitiveness of rice with the pigeon pea. As a result, both yield and biomass of rice in the intercrop treatments was considerable reduced.

Statistically significant differences ($P < 0.05$) in pigeon pea biomass and yield were also found between several of the treatments tested. The yield of sole pigeon pea (Treatment 2) was 515 kg $ha^{-1}$. Intercropping pigeon pea into rice as strip or row intercrop increased pigeon pea grain yield by 10%, and dry biomass by 3% (Treatment 5) even though some of the planted area was occupied by the rice crop. However, it was not statistically significant difference from Treatments 2 and 8 in terms of both above ground biomass and yields.

### 4.2.3 Productivity of rice/pigeon pea intercropping

According to the experimental results intercropping pigeon pea into rice (Treatment 4, 5, and 8) resulted in LER greater than unity for yields (Table 4.7). Intercropping pigeon pea into rice at high density (Treatment 5 and 8) also resulted in high efficiency for biomass production.

Table 4.6 Analysis of Variance results.

| Treatment | Rice [a)] | | Pigeon pea [b)] | |
|---|---|---|---|---|
| | Yield (kg ha$^{-1}$) | Straw (kg ha$^{-1}$) | Yield (kg ha$^{-1}$) | Biomass[c)] (kg ha$^{-1}$) |
| 1. Sole rice (RI100%) | 1,212 a | 2,233 a | -- | -- |
| 2. Sole pigeon pea (PP100%) | -- | -- | 515 a | 1827 a |
| 3. 50%RI:50%PP strip cropping | 386 c | 783b c | 296b c | 989b c |
| 4. 75%RI:25%PP strip cropping | 696 b | 1126 b | 250 c | 751 c |
| 5. 25%RI:75%PP strip cropping | 196 d | 411de | 564 a | 1,888 a |
| 6. 50%RI:50%PP row intercropping | 51 e | 147 e | 486 ab | 1,536 ab |
| 7. 75%RI:25%PP row intercropping | 282 cd | 616 cd | 356 abc | 1,001 bc |
| 8. 25%RI:75%PP row intercropping | 0 e | 79 e | 532 a | 1779 a |
| ANOVA (P>F) | <0.01 | <0.01 | <0.05 | <0.01 |
| LSD (0.05) | 13.4 | 35.6 | 22.0 | 69.1 |
| CV (%) | 22.3 | 31.0 | 34.6 | 34.1 |

[a)] measured at harvest (145 DAS), [b)] measured at harvest (295 DAS), [c)] above ground biomass

Table 4.7. Land Equivalent Ratio of rice/pigeon pea intercropping.

| Treatment | Grain yield (kg $ha^{-1}$) | | | Above ground biomass at harvest (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|
| | Rice | Pigeon pea | LER | Rice | Pigeon pea | LER |
| 1. Sole rice (RI100%) | 1,212 | -- | 1.00 | 2,233 | -- | 1.00 |
| 2. Sole pigeon pea (PP100%) | -- | 515 | 1.00 | -- | 1,827 | 1.00 |
| 3. 50%RI:50%PP strip cropping | 386 | 296 | 0.89 | 784 | 989 | 0.89 |
| 4. 75%RI:25%PP strip cropping | 696 | 250 | 1.06 | 1,126 | 751 | 0.91 |
| 5. 25%RI:75%PP strip cropping | 196 | 564 | 1.25 | 411 | 1,888 | 1.22 |
| 6. 50%RI:50%PProw intercropping | 51 | 486 | 0.98 | 147 | 1,538 | 0.91 |
| 7. 75%RI:25%PP row intercropping | 282 | 356 | 0.92 | 616 | 1,001 | 0.82 |
| 8. 25%RI:75%PP row intercropping | 0 | 532 | 1.03 | 79 | 1,779 | 1.01 |

## 4.3 Potentials and constraints of introducing upland rice-pigeon pea intercropping systems based on household survey and field experiment

Upland rice played a very important role in rice supply for Xieng Ngeun district as well as for the province or the region. Increasing rice production by expanding rainfed or irrigated lowland areas was constrained by topography and water availability. Over 90% of the land area that was occupied by the district has a slope gradient more than 30% (Table 4.2). Therefore, any improvement, even small ones that could be made to the uplands, might have had a major impact on the local rice consumption and production. In the foreseeable future, the uplands will be even more important in food production for the district as well as the province or the region, when arable land in the plains becomes more limited. At the present, there were about 388 families (7%) who were lowland farmers but grew upland rice to supplement lowland rice production.

To protect forest resources, the Lao government wants to replace shifting cultivation with more permanent upland agriculture, that is upland rice must be rotated with a definite area. As a result, the fallow periods have been considerably shortened. The fallow periods of 2-3 years, may not be sufficient to restore soil fertility for subsequent rice crops.

To ensure rice sufficiency in the future, upland rice must be increased to meet the increasing demand. As planted areas are limited, increased production must come from the use of more efficient and productive technologies. Low-input technologies are the most appropriate for the local conditions. The low-input technologies, here, do not mean "no input", but have the following criteria:

1) Utilize as much as possible local resources that are preferable generated by the farmers themselves.
2) Well adapted to local environmental conditions (appropriate to short fallow periods, protect soils from erosion, and runoff losses).
3) Easy to apply by local farmers, especially poor ones.
4) Yield optimum products whose by-products can be used as an input for other production.
5) Able to raise farmer's income.
6) Satisfy government policy.

Intercropping pigeon pea into upland rice based cropping systems may satisfy all of the above criteria, and could be accepted by local farmers if the system was demonstrated widely and promoted by government as well as private organizations. However, the adoption of the new technology may be constrained by some factors that have to be considered:

a) Glutinous rice is the only staple food for Lao people. It can not be substituted by any other cereal crops. Therefore, the farmers might not accept the newly introduced crops into an existing rice farming system if rice yield was considerably reduced.

b) There is presently no market for pigeon pea. Therefore, there is little incentive for farmers to grow pigeon pea as a component of their farming systems.

c) Lack of knowledge on the benefits that pigeon pea has on improving the rice environment. Most of the farmers interviewed reported that they never knew that pigeon pea could improve soil fertility. They are also generally unaware of using pigeon pea seeds for food or feed for animals, such as, poultry and pigs. The farmers grow a few plants of pigeon pea along the path or nearby the hut for eating as fresh (green pod) vegetables.