CHAPTER 4

STUDY AREA AND FARMERS PRODUCTION SYSTEMS OF *SESBANIA*-RICE

4.1. Description of Study Area

San Sai district covers an area of 31,801 ha, in which 12,706 ha is used for agriculture. The study areas were Ban Mor and Ban Sri-wang-tan in Pa-Pai sub-district. Pa-Pai sub-district is located in the upper north of San-Sai district. It covers an area of 5,430.5 ha, of which 3,600 ha is used for agriculture. The area is relatively irrigated but water is less available in the dry season.

The rainy season starts from May to October. The driest period is between November and February. Normally the temperature all year is rather warm, with daily temperatures ranging from 10.5 °C-37.7 °C. Total rainfall during 1999 was 957.50 mm with the peak in May (173.7 mm). Temperature during this period varied from 16.99 to 35.12 °C. The soil is mixed with many types such as Ta Yang, Num Pong and San Sai series. The soil texture in San Sai was sandy loam soil. Results of the soil analysis indicated that soil had pH of 5.87, organic matter of 1.43 %, nitrogen of 0.08 %, phosphorus and potassium of 52 and 50 ppm, respectively.

The study area is a lowland area. The Mae Fack irrigation system is a major source of water for the area. Better access to irrigation system has encouraged farmers to grow crops all year round. The area has the potential for lowland intensive agriculture areas of Chiang Mai province.

Pa Pai sub- district is administratively divided into 16 villages. It has the total population of 10,213 persons, comprising 2,489 households. Of the total households, 989 househlods (≈ 40%) are engaged in agriculture. The population in Ban Mor and

Ban Sri Wang Tan are 301 and 642 persons, comprising 68 and 182 households, respectively. Approximately, 79 percent and 69 percent of the households in Ban Mor and Ban Sri Wang Tan are dependent primarily on agriculture. Of the agricultural area, paddy field covers 65 ha. Common rice varieties being grown in Pa Pai sub-district in the rainy season were KDML-105 and RD. 6. The average yields of KDML-105 and RD. 6 varieties were 3.75 t ha^{-1} and 4.25 t ha^{-1}, respectively. Rice is used mainly for home consumption, while the excess paddy is sold. In addition, after harvesting rice, farmers grow a number of cash crops such as soybean, tomato, cucumber, yardlong bean, or other vegetables as source of family's additional incomes.

4.2. Cropping System

The study area at San-Sai district is part of the irrigated lowland rice. Its predominant cropping pattern is characterized as a double cropping system such as rainy season rice-soybean-fallow, rainy season rice-cash crop-fallow, rainy season rice-dry season rice. The rainy season rice cultivation, for household consumption as well as for various commercial purposes, starts in July and harvesting usually starts from late November to early December. The second crops such as soybean are planted after rice towards the end of December to early January. Soybean is harvested during April. The other cash crops such as yardlong bean are harvested 2 months after planting. Then the land is left fallow after the second crop harvest. Cropping patterns in the study area is shown in Figure 3.

In some cases, farmers used *S. rostrata* as green manure with rainy season rice. The *S. rostrata* seed was broadcasted at 20 kg ha^{-1} in mid-May and allowed to grow for 45-60 days. The *S. rostrara* seeds were soaked in hot water or in sulfuric acid to soften their hard seed coat and break dormancy before broadcasting. *S. rostrata* was incorporated into the soils in early of July. They were incorporated into the soil at 5 to 7 days before the rice was transplanted. Seedlings of 30 to 35 days old were usually used. The rice varieties most commonly selected by farmers in this area were RD. 6 and KDML 105. Some farmers adopted the newly introduced klong-luang variety. Rice was harvested from late November to early December.

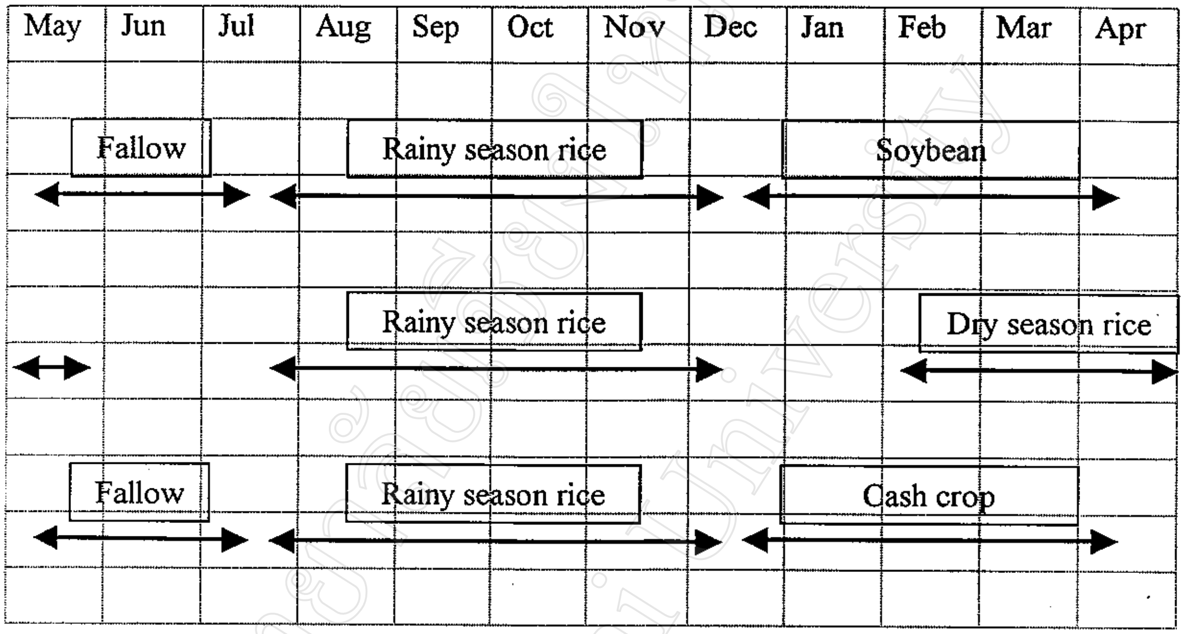

Figure 3. Cropping pattern in the study area

4.3. On-farm research in rainy season rice in 1999

The results of the on-farm research on farmers' management practices conducted in 1999 revealed that *S. rostrata* grown by the farmers an average height of 92.9 c.m and density of 62 plant per m^2. Fresh bio-mass was 5.72 t ha^{-1}. An average dry biomass was 1.12 t ha^{-1}.

Rice yields of *S. rostrata* incorporated with chemical fertilizer plots were estimated from three varieties of rice including Klong-luang, KDML 105 and RD.6. Yield of Klong-luang variety varied from 3.77 to 6.35 t ha^{-1}, with an average of 4.79 t ha^{-1}. Yield of KDML 105 varied from 3.31 to 4.48 t ha^{-1},with an average of 3.85 t ha^{-1}. RD. 6 was about 3.47 t ha^{-1}. Average numbers of panicle per m^2 of Klong-luang, KDML 105 and RD. 6 varieties were 173, 168 and 118 panicles, respectively.

In case that farmer used only chemical fertilizer the rice yield of KDML 105 variety varied from 1.76 to 4.69 t ha^{-1}, with an average of 3.33 t ha^{-1}. The yield of RD. 6 variety varied from 2.6 to 4.5 t ha^{-1}, with an average of 3 t ha^{-1}. But in case when only *S. rostrata* was used as green manure the sampling showed that average yields of KDML 105 and RD.6 varieties were 3.75 t ha^{-1} and 5.16 t ha^{-1}, respectively.

Results of the informal survey conducted during the 1999 rainy season rice revealed that 89 % of farmers interviewed (n = 28) who used *S. rostrata* as green manure still applied chemical fertilizer in *S. rostrata* plots. The application rates varied from 7.5 kg N ha^{-1} to 31.0 kg N ha^{-1}. For those who did not use *S. rostrata* normally apply chemical fertilizers at the rates from 7.8 kg N ha^{-1} to 50.0 kg N ha^{-1}.

4.4. Follow-up field survey on farmers' fertilizer management practices following the introduction *S. rostrata* (2000)

Results of the field survey conducted in year 2000 revealed that area devoted to rice production in the study area ranged from 0.40 ha to 2.72 ha per household, with an average of 1.35 ha. KDML 105 and RD. 6 varieties were the most popular varieties among rice growers because both varieties could sold with good price. No farmer grew the Klong-luang variety because of its low price in the market and low eating quality as compared to KDML 105. Most of rice varieties grown in the dry season were glutinous ones. The most preferable varieties included RD6, RD 10, RD 2, RD 4 and Sanpathong.

4.4.1. Fertilizer management by farmers in the study area

The field survey indicated that farmers had several methods of recovering soil fertility such as the use of animal manure, incorporating weeds into the soils, and growing leguminous species such as soybean and peanut after rainy season rice. However, the use of *S. rostrata* as green manure was quite new for the farmers.

4.4.2. Chemical fertilizer-based management practice

Applying chemical fertilizers to rice production is a common practice of farmers in the study area. As shown by this study, 96% of farmers interviewed (n = 39) reported using chemical fertilizer in both dry and rainy rice production systems. The remaining 4% of the farmers did not use any chemical fertilizers. The common compound fertilizers used were 16-20-0 and 46-0-0. Farmers usually practiced a split-application of fertilizers at two stages, i.e., at 30 days after transplanting and booting stage.

Average application rates of the 16-20-O and 46-0-0 compound fertilizers used by farmers in the rainy season rice were 28 kgN ha^{-1} and 22 kgN ha^{-1}, respectively, while those used in the dry season rice were 32.8 kgN ha^{-1} and 40.5 kgN ha^{-1}, respectively. Overall, rainy season rice received an average chemical fertilizer application at the rate of 50.0 kgN ha^{-1}, while the dry season rice received an average application at the rate of 73.3 kgN ha^{-1}. The average cost of chemical fertilizer in rainy season rice was 1,555 Baht ha^{-1}and in dry season was 2,106 Baht ha^{-1}. The rates of chemical fertilizer application and their costs practiced by farmers in the study area are showed in table 3.

Table 3. Average amount of chemical fertilizer application by farmers

Type of fertilizer	Rainy season (n = 36)			Dry season (n = 36)		
	Average (kgN ha^{-1})	Unit cost (Baht kg^{-1})	Total cost (Baht ha^{-1})	Average (kgN ha^{-1})	Unit cost (Baht kg^{-1})	Total cost (Baht ha^{-1})
16-20-0	28.0	6.75	1,188	32.8	6.87	1,408
46-0-0	22.0	7.65	367	40.5	7.93	698
Overall average	50.0		1,555	73.3		2,106

Source: Farmer interview 2000. * n = number of farmers reported applying chemical fertilizers.

4.4.3. *S. rostrata*-based management practice

In the *S. rostrata*-based rice production system, an interviewed found that 70% of the interviewed farmers (n = 39) did not apply any chemical fertilizer. The other twelve farmers (30%) still applied chemical fertilizer in *S. rostrata* plot because they were not confident in the efficiency of *S. rostrata*. However, the estimates could not be made since the farmers did not remember the amount of fertilizer applied. These farmers normally broadcasted little amount of chemical fertilizer only when they saw poor growth of rice (e.g. yellowish or stunted growth) in some part of the fields.

Seventy-five percent of farmers reported that incorporation of *S. rostrata* as green manure increased rice yields from 10 to 20%, but 25% of the farmers found that rice yields obtained from the *S. rostrata* plots were not different from those in the chemically fertilized plots. Average yields of rice under the two management practices are presented in Table 4.

Table 4. Average yields of rice under each management practice.

Rice variety	Average yield (t ha^{-1})		% increasing
	Chemical fertilizer	*S. rostrata*	
RD.6	3.28	3.87	19
KDML 105	3.89	4.25	9.2

4.5. Cost of using of *S. rostrata* as green manure in lowland rice

The average cost of *S. rostrata* cultivation was 6,357 Baht ha^{-1}, including land preparation of 2,321 Baht ha^{-1}, labor and management of 193 Baht ha^{-1}, *S. rostrata* incorporating of 3,280 Baht ha^{-1}, and seed cost of 563 Baht ha^{-1} (Table 5).

Table 5. Cost of the use of *S. rostrata* as green manure in lowland rice.

Items	**Number of farmers** (n = 39)
Land preparation before broadcasting *S. rostrata* seeds (Baht ha^{-1})	2,322
Labor and management (Baht ha^{-1})	193
S.rostrata incorporating (Baht ha^{-1})	3,280
Seeds cost (Baht ha^{-1})	563
Total	6,358

Since farmer must plow before they grow rice, then the cost of incorporating *S. rostrata* was only 3,077 Baht ha^{-1}.

Furthermore if the farmers broadcast *S. rostrata* seeds without plowing, the cost of using of *S. rostrata* as green manure in lowland rice was reduced by 2,321 Baht ha^{-1}. The total cost was 4,036 Baht ha^{-1}. However the interview found that without plowing emergence rate of *S. rostrata* seeds was low. The low population density would lead to dry biomass yield and total N in the soil.

4.6. Cost and return of lowland rice production system

The variable costs included rice seed, chemical fertilizer, pesticide, herbicide, and labors. The cost could be divided into cash and non-cash expenses. Non-case express included the opportunity cost of inputs such as family labor, and own rice seeds. Cash expenses included various expenditures, which had actually been occurred. The cost and net return were calculated at actual prices paid and received by farmer.

As shown in Table 6 about 38% of cash cost was a material cost and 62% was labor cost. Material cash cost included rice seeds, fertilizer, pesticide and herbicide. About 50% of material cost paid for chemical fertilizer. Labor cash cost included land preparation and planting and harvesting costs. About 64% of labor cast cost paid for land preparation and planting. Non-cash included land preparation, planting, management and harvesting.

Table 7 presents all the investment costs of the rice production system that receive only *S. rostrata* as green manure. It can be seen that material cost consume 17%, while the labor cash cost consumed 83% of the total cost. Material cash cost included rice seeds, pesticide and herbicide. Labor cash cost included land preparation and planting, harvesting, land preparation before *S. rostrata* seeds broadcasting and management of *S. rostrata* costs. About 74% of labor cash cost paid for land preparation both before *S. rostrata* broadcasting and before planting rice. Non-cash included land preparation and planting, management and harvesting.

Table 6. Variable cost of lowland rice production system receiving chemical fertilizer application.

Items	**Cash (Baht ha^{-1})**	**Non-cash (Baht ha^{-1})**	**Total (Baht ha^{-1})**
Material cost	3,107	0	3,107
- Rice seeds	542	0	542
- Fertilizer	1,555	0	1,555
- Pesticide	557	0	557
- Herbicide	453	0	453
Labor cost	5,093	7,819	12,912
- Land preparation and planting	3,278	3,666	6,944
- Management	0	1,596	1,596
- Harvesting	1,815	2,557	4,372
- Other	0	0	0
Total variable cost	8,200	7,819	16,019

Table 7. Variable cost of lowland rice production system receiving *S. rostrata* as green manure.

Items	Cash (Baht ha^{-1})	Non-cash (Baht ha^{-1})	Total (Baht ha^{-1})
Material cost	1,552	0	1,552
- Rice seeds	542	0	542
- Fertilizer	0	0	0
- Pesticide	557	0	557
- Herbicide	453	0	453
Labor cost	7,607	7,819	15,426
- Land preparation and planting	3,278	3,666	6,944
- Management	0	1,596	1,596
- Harvesting	1,815	2,557	4,372
- Other			
1. Land preparation before *S. rostrata* seeds incorporation	2321	0	2321
2. Management	193	0	193
Total variable cost	9,159	7,819	16,978

4.7. Return of rainy season rice production system of fertilizer application and incorporating of *S. rostrata* as green manure

RD. 6 and KDML 105 were the most favorite rice variety of rainy season rice in Chiang Mai lowland. An average yield of RD.6 and KDML 105 were 3.29 and 3.89 t ha^{-1} when applied chemical fertilizer. Average farm prices of both varieties were 5,300 and 6800 Baht t^{-1}, respectively. Total incomes were 17,437 Baht ha^{-1} for RD.6 variety and 26,452 Baht ha^{-1} for KDML 105. Total cost per ha of RD.6 and KDML 105 varieties was 16,019 Baht ha^{-1}. Then net returns per ha of RD.6 and KDML 105 varieties were 4,525 Baht ha^{-1} and 10,433 Baht ha^{-1}.

However an average yields of RD.6 and KDML 105 were 3.87 t ha^{-1} and 4.25 t ha^{-1}, respectively, when incorporating *S. rostrata* as green manure. Rice yield increased about 9-19% when compared with applying of chemical fertilizer. Average farm prices of both varieties were 5,300 and 6,800 Baht ha^{-1}, respectively. Total incomes were 20,511 Baht ha^{-1} for RD.6 variety and 28,900 Baht ha^{-1} for KDML 105. Total cost per ha of RD.6 and KDML 105 varieties was 16,978 Baht ha^{-1}. Then net returns per ha of RD.6 and KDML 105 varieties were 3,533 and 11,922 Baht ha^{-1}.

Table 8. Return of rainy season rice production system of fertilizer application and incorporating of *S. rostrata* as green manure.

Items	Chemical fertilizer	*S. rostrata*
Average yield (t ha^{-1})		
RD.6	3.29	3.87
KDML 105	3.89	4.25
Average farm price (Baht t^{-1})		
RD.6	5,300	5,300
KDML 105	6,800	6,800
Total income (Baht ha^{-1})		
RD.6	17,437	20,511
KDML 105	26,452	28,900
Total cost (Baht ha^{-1})	16,019	16,978
Total variable cost (Baht ha^{-1})	7,819	7,819
Total cash cost (Baht ha^{-1})	8,200	9,159
Net return (Baht ha^{-1})		
RD.6	4,525	3,533
KDML 105	10,433	11,922

4.8. Discussion

Rice crop is unique in that it uptakes a huge amount of N from the soil annually. It is therefore important that soil fertility maintained if sustainability of rice production is to be achieved in the long run. It requires the return of nutrients into the soil for the amount lost. Traditionally, this can be done by applying chemical fertilizers. However, this practice is generally not considered as a promising option for the majority of poor-resource Thai rice farmers due to the fact that the cost of fertilizers in Thailand is high as compared to per capita income (Fuglie, 1986; Arunin *et al.*, 1988). This clearly reveals that other better alternatives must be sought out. Recently, it has been widely recognized that green manures are the best alternative fertilizer sources that when integrated into the systems do a lot to improve and sustain soil fertility for rice crop.

Chiang Mai province has been typified as a particular area with several particular potentials for the successful integration of green manure crops into the lowland rice-based cropping systems. One of the cases has been the favorable cropping system. As found by this study, although the area is commonly characterized by three different cropping patterns, i.e., rice-soybean, rice-rice, and rice-cash crops, the land is normally left fallow for over three months (mid or late April mid-June) after the second crop harvest. It is thus obvious that the *S. rostrata* green manure can be grown in this follow period, where there is also abundant rainfall. The engagement of the Multiple Cropping Center of Chiang Mai University in promoting the adoption of *S. rostrata*, although at its infant phase, has well justified the importance of the need for the introduction of *S. rostrata* into Chiang Mai valley lowland rice-based cropping systems, and which has received increasing recognitions among the local rice farmers.

Results of the follow-up field survey on farmers' fertilizer management conducted in the year 2000 growing season revealed that although the lowland rice production system in the studied area has been marked as a low-input one, the use of external fertilizer input appeared to be relatively high. Both the rainy and dry season rice received chemical fertilizer application rates on average at 50.0 kgN ha^{-1} and 73.3 kgN ha^{-1}, respectively. The 16-20-0 compound fertilizer was the common type used by the farmers. Farmers in the study area have traditionally practiced several techniques, for example, use of animal manure, incorporation of weeds into the field, and growing legumes such as soybean and peanut after rainy season rice, to improve soil fertility. Nevertheless, farmers had little knowledge about the *S. rostrata* green manure. Only the past two years has this new green manure species been introduced to them by the Multiple Cropping Center of Chiang Mai University.

From the two years of experience in conducting the collaborative trials with this research and development agency, the majority of farmers (75%) have tended to acknowledge the potential of *S. rostrata*. These farmers reported that the incorporation of *S. rostrata* into the fields increased rice yields from 9 to 19% compared with the fields receiving only chemical fertilizer application. The other 25% of farmers, however, reported a non-different rice output between the two practices. The reports made by these farmers may be reliable. But the case may be resulted from the high chemical fertilizer application rates among these farmers, which led to a better crop yields in their fertilized fields. On the other hand, the insignificant yield increase in the *S. rostrata* fields may be associated with the poor establishment of the *S. rostrata* green manure due to the farmers' poor management practices.

Results of the on-farm study in rainy season rice of 1999 of the *S. rostrata* growth and biomass yield potential showed that *S. rostrata* grown in the study area yielded an average dry biomass at 1.78 t ha^{-1}. This yield is much lower than that of the on-station grown *S. rostrata*. According to Gypmantasiri *et al.* (2000), average dry biomass of *S. rostrata* grown from 1993 to 1998 at the Irrigated Research Station of Chiang Mai University varied from 2.8 to 3.68 t ha^{-1}, with an overall average of 3.14 t ha^{-1} . The large yield gap between the on-station and the on-farm grown *S. rostrata* suggests that the poor *S. rostrata* production may be associated more or less with the poor crop establishment.

As pointed out by Palaniappan (1994), an increased quantity of biomass associates primarily with the good establishment of the green manure crop. A number or practices that should be considered when attempting to achieve a good crop establishment includes adequate seedbed preparation, breaking the dormancy of the seed, proper methods of sowing, and optimum plant density. Moreover, drought or waterlogging stress at critical growth phases of green manure crop, pests, and diseases may also pose problems in the way of a good crop stand and biomass production. The low biomass produced would lead to low amount of nitrogen released to the soil (Hamman, 1991).

Rice grain yields of the KDML 105 and RD.6 variety commonly grown by the farmers under the *S. rostrata*-based production system, based on the year 2000 data, were respectively 9% and 19% higher than those under the sole chemical fertilizer-applied systems (Table 4). This apparently demonstrated that *S. rostrata* had a positive effect on yields. An inference to be made with regards to the higher rice yields obtained from the *S. rostrata* is that the observed amount of *S. rostrata* biomass grown on the farmer fields, though relatively low compared with the on-station records, could have released a higher level of absorbable N for rice crop as compared to that released from the applied chemical fertilizers. This released amount of N when added with chemical fertilizers would have a greater positive effect on rice yield, regardless of soil types. This has been true according to Arunin *et al.* (1994 & 1995) who showed that rice receiving both *S. rostrata* and fertilizer gave higher yields than that receiving only green manure, at 90%, for non-saline soil, and 29%, for saline soil. For this study, rice yield data of the KDML 105 variety (3.85 t ha^{-1}) obtained in 1999 growing season from fields receiving *S. rostrata* with chemical fertilizer application at the rates from 7.5 to 31 kgN ha^{-1} were also found to be higher than those under the fields receiving only chemical fertilize and *S. rostrata*. But the increased rate was too small that can be assumed to be insignificant. A substantial yield response of 5.16 t ha^{-1} during same growing season of rice receiving only *S. rostrata* was recorded with the RD.6 variety. This data cannot, however, be correctly verified as the rice yield under this same management system during the year 2000 was not obtained. Majority of farmers interviewed reported that no chemical fertilizer was added to the *S. rostrata* fields. Only a few that reported applying chemical fertilizer, but the amount was very little that they could not remember.

The financial benefits of using green manure are realized in terms of increased rice yields with reduced fertilizer costs (Garrity *et al.*, 1994). These were also proved by this study. At the first glance at Tables 6-8, the replacement of chemical fertilizers with *S. rostrata* reduced cost of production coming from fertilizer costs on average by 1,555Baht ha^{-1}. The total net returns (Table 8) of the two rice varieties, KDML 105 and RD. 6, grown in the fields with *S. rostrata* incorporation turned out to be greater than those obtaining from the fields receiving chemical fertilizer. Increased cost of production about 6% compared with the using of chemical fertilizer is not a main constraint that may restrain farmers from adopting *S. rostrata* as a source of nutrient for their fields.

It is clear that incorporation of *S. rostra* leads to positive response from lowland rice in the study area. The increase rates of 9 to 19% compared to the fertilized fields were promising to bring about a considerable increase in incomes to the farmers.