RESULTS

Informal and formal surveys

Sources and management of organic matter

The results of informal and formal surveys indicated that the main sources of organic matter in rice-soybean cropping systems were residues of soybean, rice straw, and animal manure. Crop residues constituted the major sources for organic recycling in the crop production system. Farmers' management of crop residues in this system could be classified as leaving and incorporating the residues into the soil, burning them, using them as feed to animals and using them in making compost. Animal manures were used in both rice and soybean production. The flow of these organic materials in rice-soybean cropping system is shown in Figure 1.

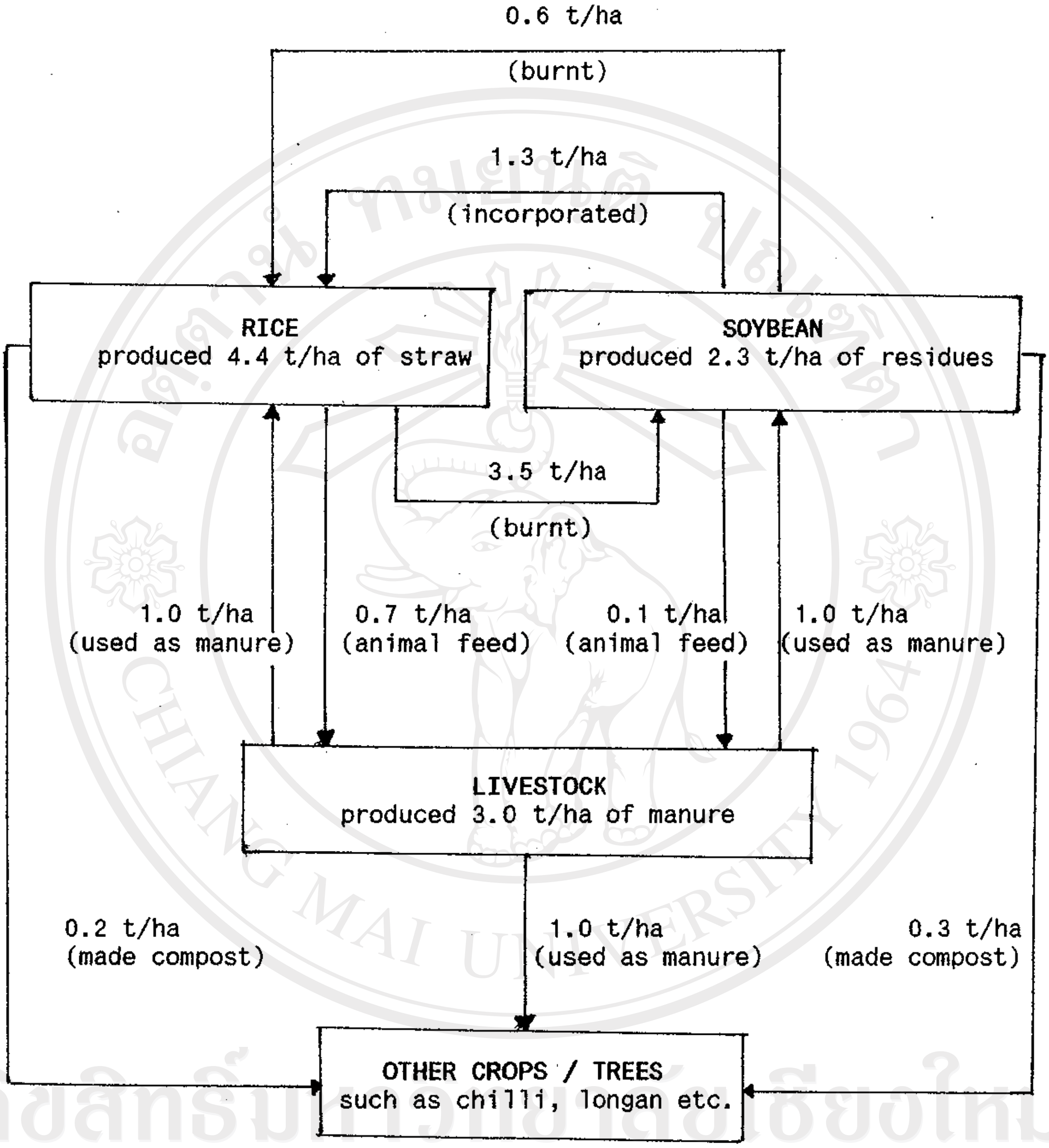

Figure 1. The flow of organic matter in rice-soybean cropping system

Soybean residues

The formal survey showed that 54.8% of the farmers left soybean residues in the fields and incorporated them to the soil, 16.6% of the farmers burnt all soybean residues, 14.3% converted residues to compost and another 14.3% burnt half and fed half to the animals as shown in Table 2.

Table 2. Soybean residue management in the farmers' fields

Management	% of farmer
1. Left and incorporated into the soil	54.8
2. Burnt all	16.6
3. Made compost	14.3
4. Burnt 50% and fed animal 50%	14.3
Total	100.0

It is apparent that the majority of the farmers incorporated soybean residues to the soil by spreading over the field during land preparation for rice. Soybean residue was found to be an important source of organic matter currently used by farmers in rice-soybean cropping system.

Table 3. The amount and nutrient content of soybean residues in the farmers' fields

Sample	Residues (t/ha)	Nutrient content(%) N	P	K
1	2.0	1.05	0.08	0.30
2	2.4	0.96	0.06	0.40
3	3.7	0.99	0.11	1.53
4	3.0	0.80	0.07	1.73
5	1.7	0.99	0.07	0.70
6	1.8	0.78	0.07	1.23
7	2.8	0.98	0.18	1.78
8	2.9	1.34	0.17	1.60
9	1.3	0.78	0.07	1.30
10	1.5	0.66	0.07	1.15
Mean	2.3	0.93	0.10	1.17

Table 3 shows the amount and nutrient content of soybean residue in farmers' field. The average amount of soybean dry matter, consisting of stems, branches, leaves and pods were about 2.3 t/ha with 0.93% of total nitrogen, 0.10% of phosphorus (P) and 1.17% of potassium (K)

Rice straw

More than 50% of the farmers wasted rice straw by burning. A small amount of rice straw was kept as feeds for animals and was made as compost (Table 4). Farmers spread the rice straw in the field and burnt it before sowing soybean in order to control and prevent weeds. The farmers reasoned that if they did not burn it, they would need higher amount of herbicides and would apply it more frequently. This may result in higher expenditures and detrimental effects to the environment. Thus, rice straw was not an available source of organic matter in this system.

Table 4. Rice straw management in farmers' fields

Management	% of farmers
1. All straw burnt	50.0
2. 90% burnt and 10% for feeding	14.3
3. 50% burnt and 50% for feeding	28.6
4. 50% burnt and 50% for making compost	7.1
Total	100.0

The analysis of rice straw including stubble from the farmers' fields showed that the total nitrogen, phosphorus (P) and potassium (K) were about 0.5%, 0.18% and 2.49%, respectively. The amount of rice straw varied from 3-5 t/ha (Table 5).

Table 5. The amount and nutrient content of rice straw in the farmers' fields

Sample	Straw (t/ha)	Nutrient content(%) N	P	K
1	4.6	0.42	0.15	2.48
2	3.8	0.42	0.15	2.68
3	4.1	0.53	0.18	2.65
4	4.8	0.47	0.19	2.34
5	4.7	0.44	0.15	2.41
6	4.7	0.52	0.17	2.09
7	5.6	0.59	0.20	2.10
8	4.0	0.58	0.18	2.38
9	3.3	0.52	0.20	2.54
10	4.2	0.51	0.18	2.31
Mean	4.4	0.50	0.18	2.49

The survey showed that the average farm size of farmer in this system was about 1 ha/household. The quantity of soybean residues and rice straw used for various purposes were estimated and shown in Table 6 and Table 7.

Table 6. The amount and management of soybean residues in the farmers' fields

Management	Amount(t/ha)	% of residues
1. Incorporating into the soil	1.3	57
2. Burning	0.6	26
3. Making compost	0.3	13
4. Feeding	0.1	4
Total	2.3	100

Table 7. The amount and management of rice straw in the farmers' fields

Management	Amount(t/ha)	% of straw
1. Burning	3.5	79
2. Feeding	0.7	16
3. Making compost	0.2	5
Total	4.4	100

Animal manure

Apart from using crop residues, farmers also used animal manure particularly that of the cattle but the use of chemical fertilizer had largely replaced the use of the manure. The formal survey showed that during the rice season about 40.5% of the farmers used chemical fertilizer (16-20-0 or urea), 38.1% of them used chemical fertilizer combined with animal manure, while 14.3% of them used only animal manure (Table 6). They applied chemical fertilizer at the total rate of 125-187.5 kg/ha in two applications, one or two weeks after transplanting and at the panicle initiation stage (30-45 days after transplanting). The animal manure was spread and plowed during land preparation at a rate of 625-935 kg/ha.

In soybean fields, the survey indicated that 47.6% of the farmers used chemical fertilizer (16-20-0 or 15-15-15) at the total rate of 95-156 kg/ha during flowering stage and at the beginning of seed development. About 35.7% of the farmers used chemical fertilizer and 9.6% used animal manure as shown in Table 8.

Table 8. Animal manure and chemical fertilizer used in the rice fields and the soybean fields

Fertilizer utilization	Rice field (% of farmer)	Soybean field (% of farmer)
1. No fertilizer	7.1	7.1
2. Animal manure	14.3	9.6
3. Chemical fertilizer	40.5	35.7
4. Animal manure + chemical fertilizer	38.1	47.6
Total	100.0	100.0

Analyses of soil samples gathered from the farmers' fields showed that the C/N ratio of the manure was about 17 with 0.62% of total nitrogen, 0.09% of phosphorus (P), and 1.63 % of potassium (K) as shown on Table 9.

Fifty five percent of the farmers owned cattle with the average size of 2 cattle/household. This would provide animal manure of about 3 t/year or 3 t/ha since one cattle could provide about 1.5 t of manure per year (Osotspa, 1981) and assuming that one-third of these manure was used for rice crop and one-third for soybean.

Table 9. C/N ratio and nutrient content of animal manure in the farmers' fields

Sample	C/N ratio	Nutrient content(%)		
		N	P	K
1	26	0.57	0.20	2.64
2	21	0.44	0.07	1.28
3	27	0.56	0.07	1.25
4	14	0.72	0.12	1.90
5	11	0.66	0.09	1.88
6	27	0.59	0.10	0.94
7	11	0.76	0.02	1.31
8	29	0.58	0.11	2.48
9	12	0.68	0.04	1.20
10	19	0.62	0.09	1.41
Mean	17	0.62	0.09	1.63

Green manure

Sesbania rostrata appears to be a potential source of nitrogen nutrient and organic matter for rice. Labor availability and competitive use of labor for other important farm operations or off-farm income generating activities during that period needed to be explored. The survey showed that 52.4% of the farmers in the soybean area were unemployed during June and July. Only 26.2% of them had off-farm employment (Table 10). It was also found that the farmers in the surveyed areas had never tried green manure because of their unawareness of these crops. Only two out of forty two respondents knew the usefulness of green manure from the information shown on the television.

Table 10. Farmers' activities during April-July

Activities	% of farmer
1. Unemployment (staying at home)	52.4
2. Off-farm employment	26.2
3. Growing chilli	4.8
4. Selling non-farm commodities	7.1
5. Others	9.5
Total	100.0

Potential constraints in increasing soil productivity through organic replenishment

Although the amount of rice straw available was as high as 3-5 t/ha, the benefits of incorporating rice straw was poorly realized by the farmers in rice-soybean cropping system. Thus, burning rice straw before growing soybean is still a common practice hence preventing the use of them for organic recycling in the crop production system. Fifty percent of the farmers strongly believed that burning rice straw before sowing soybean could reduce the incidence of weeds, insects and diseases and the straw ash could be used as a source of fertilizer for soybean. Moreover, burning rice straw facilitates land preparation particularly in the short turn around period (15-20 days) prior to growing soybean.

In contrast, majority of soybean residues in this system were incorporated back to the field. Most farmers (54.8%) left soybean residues as a pile for a period of time until soybean mushroom sprouted and were harvested. Then, they incorporated the soybean residues into the field during land preparation for the rice crop. However, the amount of soybean residues found in the farmers' practice was too low to adequately return nutrient and organic matter to the soil. Incorporation of soybean residues alone may not be sufficient for rice production. It is necessary to use the combination of soybean residues and chemical fertilizer to maintain agricultural production and soil fertility.

In case of animal manure, only 33% of the farmers had an average of 2 cattle per household that could provide manure of about 3 t/year. This amount was distributed to rice and soybean crops particularly for covering soybean seed after sowing. However, the manure was available only in the farms where the cattle were raised.

Besides, the lack of knowledge on the use of green manure crop in this system was an important obstacle to maintain soil productivity through organic matter replenishment. However, about 42.9% of the farmers responded that if green manure contributes to improving yield and net income, they were willing to participate in the plot trials before adopting this technology.

Based on the results from the formal survey, a field experiment with aspects of returning crop residues to the soil and incorporating green manure crop should be conducted in order to study the effect of organic matter to the soil and rice crop. Although the main crop residues in rice-soybean cropping system are straw and soybean residues, straw is not the practical source of organic matter since it is burnt before sowing soybean. Soybean residues may be returned to the soil then incorporated during land preparation for planting rice. However, soybean residues alone can not adequately supply the nutrients and organic matter to the soil. The use of soybean residues should be supplemented with inorganic fertilizer. Alternative sources of organic nitrogen should be investigated particularly *Sesbania rostrata* during the fallow period between May to July since the labor use for *Sesbania rostrata* was available. Moreover, analysis of the average flow rate of Mae Taeng Irrigation as well as the mean monthly rainfall which was measured at Sanpatong Rice Station (1965-1990) (Figure 2) revealed adequate water supply for growing *Sesbania rostrata* during this period. Thus, this crop could be incorporated in the soil as green manure for the subsequent paddy rice.

Therefore, these alternative strategies should be evaluated in rice-soybean cropping system for their feasibility and economic viability before farm trials in the broader scale are conducted.

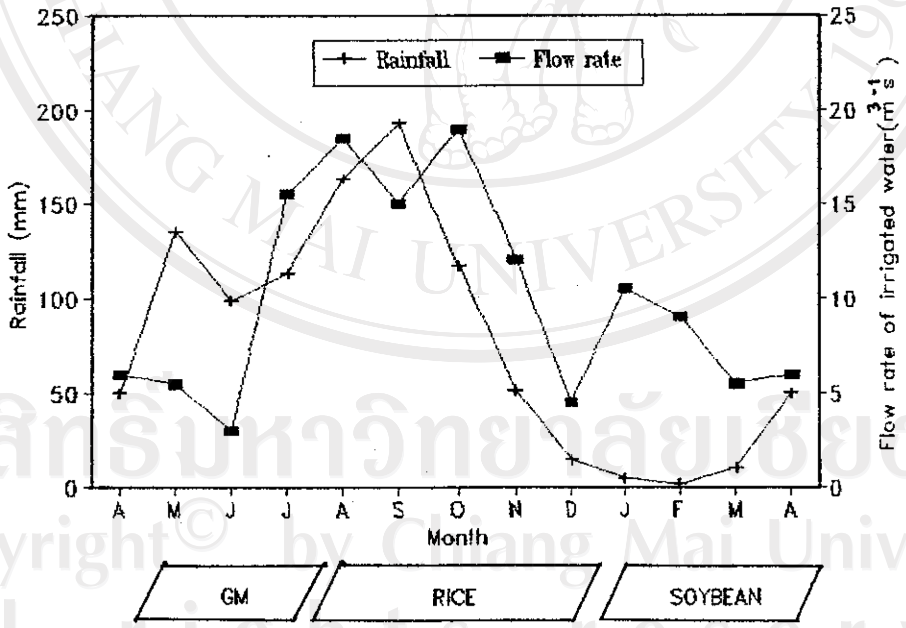

Figure 1. Green manure(GM) and rice-soybean cropping system in Chiang Mai Valley in relation to rainfall and irrigation water distribution

Field experiment

Some characteristics of *Sesbania rostrata*

Sesbania rostrata at 50 days old sampled from the experimental plots was analyzed for physical and content characteristics. *Sesbania rostrata* could produce about 15 t/ha of biomass (2.9 t of dry matter per ha) with 111 plants/m^2. The total nitrogen, phosphorus(P) and potassium(K) were about 88.5, 9.6 and 62.8 kg/ha, respectively while the carbon content was 37% (Table 11).

Table 11. Plant density, biomass, dry matter, nutrient accumulation and carbon content of *Sesbania rostrata* at 50 days old

Sample No.	Plant density (plant/m^2)	Biomass (fresh) (t/ha)	Dry matter (t/ha)	Nutrient accumulation N	P	K	Carbon (%)
				--------(kg/ha)--------			
1.	90	15	2.5	84.5	9.3	51.2	34.1
2.	116	15	2.8	91.9	8.2	37.5	45.4
3	128	13	2.5	68.5	7.3	65.2	34.3
4	119	15	2.8	88.5	8.8	46.5	32.1
5	73	14	2.9	72.5	11.1	81.6	34.7
6	142	19	3.9	125.2	12.9	94.9	41.3
Mean	111	15	2.9	88.5	9.6	62.8	37.0

Shoot dry matter of rice

At the panicle initiation stage, incorporation of *Sesbania rostrata* showed significantly higher shoot dry matter than the other treatments (Table 12). However, after the panicle initiation stage no difference in shoot dry matter was detected as shown in Figure 3. There was no significant difference between shoot dry matter of the two rice varieties.

Table 12. The shoot dry matter (t/ha) of rice as influenced by different N sources averaged over varieties at panicle initiation stage

N-sources	Rice variety		Mean
	RD7	KDML105	
1. No N-fertilizer	2.6	3.1	2.9
2. Urea at 50 kgN/ha	3.0	2.9	2.9
3. Soybean residues at 1.25 t/ha	2.7	3.5	3.1
4. Soybean residues at 1.25 t/ha + urea 35 kgN/ha	2.9	3.0	3.0
5. *Sesbania rostrata*	3.6	3.6	3.6
Mean	3.0	3.2	

$LSD_{0.05}$ for N sources = 0.5 t/ha, no significant difference between varieties.

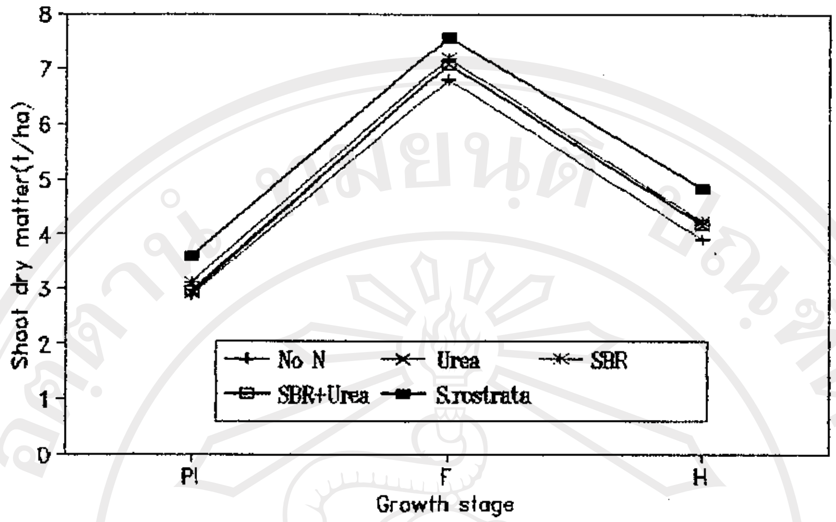

Figure 3. Shoot dry matter of rice as influenced by different N sources averaged over varieties at panicle initiation stage (PI), flowering stage (F) and harvesting stage(H)

N-uptake in straw and grain of rice

There was no significant effect of rice varieties on N-uptake in straw at any stage (Table 13). However, among the N sources, the N-uptake in rice straw at the panicle initiation stage was distinctly higher in the *Sesbania rostrata* treatment while no differences were observed at flowering and harvesting stages (Figure 4).

Table 13. Average N-uptake (kgN/ha) in straw of RD7 and KDML105 at different stages

Rice varieties	Panicle	Flowering	Harvesting
RD7	39.3	51.7	21.3
KDML105	39.1	51.3	22.2
	ns	ns	ns

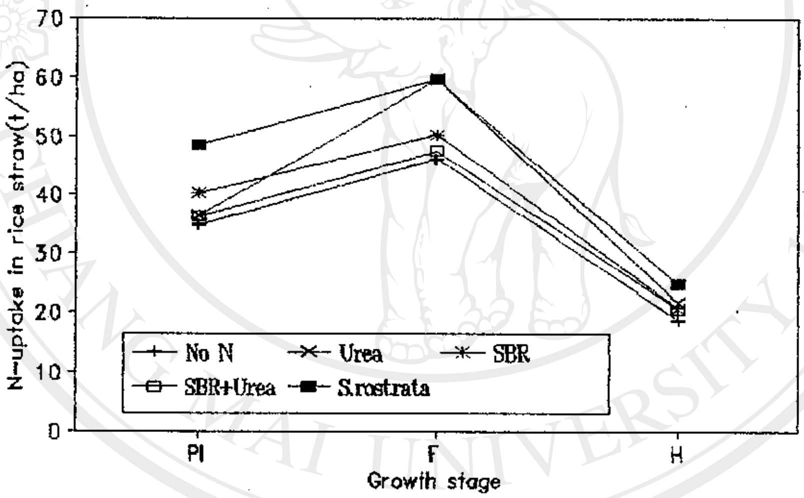

Figure 4. N-uptake in rice straw at panicle initiation stage(PI), flowering stage(F) and harvesting stage(H)

In case of N-uptake in rice grain, There was an interaction between varieties and N sources. The N-uptake in rice grain depended significantly on rice varieties, RD7 responded to urea treatment best with the average N-uptake of 42.14 kgN/ha while KDML105 responded favorably to *Sesbania rostrata* and soybean residues plus urea treatments with the average N-uptake of 52.62 and 45.15 kgN/ha, respectively. The N-uptake in grain of these two varieties also depended significantly on N sources. No N fertilizer, applications of urea and soybean residues alone did not give significant difference in grain N-uptake, however, incorporation of soybean residues plus urea and *Sesbania rostrata* showed significant difference between these two varieties (Table 14).

Table 14. N-uptake (kgN/ha)in rice grain of various treatments

N-sources	Rice variety	
	RD7	KDML105
1. No N-fertilizer	36.96	36.36
2. Urea at 50 kgN/ha	42.14	42.77
3. Soybean residues at 1.25 t/ha	33.73	40.26
4. Soybean residues at 1.25 t/ha + urea at 35 kgN/ha	34.56	45.12
5. *Sesbania rostrata*	37.88	52.62

$LSD_{0.05}$ for interaction between varieties and N sources = 7.63 kg/ha

N concentration in grain revealed significant difference between rice varieties but no difference among N sources and no interaction between rice varieties and N sources. Of the two rice varieties, KDML105 showed the higher significant N concentration in grain than that of RD7 with the average N concentration in grain of 1.06% in KDML105 and 0.97% in RD7 (Table 15).

Table 15. The N concentration (%) in rice grain of various treatments

N-sources	Rice variety		Mean
	RD7	KDML105	
1. No N-fertilizer	0.96	1.01	0.99
2. Urea at 50 kgN/ha	1.06	1.05	1.06
3. Soybean residues at 1.25 t/ha	0.94	1.08	1.01
4. Soybean residues at 1.25 t/ha + urea at 35 kgN/ha	0.94	1.06	1.00
5. *Sesbania rostrata*	0.95	1.12	1.04
Mean	0.97	1.06	

$LSD_{0.01}$ for rice varieties = 0.07%, no significant difference among N sources

Rice yield and yield components

Grain yield of rice showed significant difference among treatments with different N sources. No significant difference between varieties of rice and no interaction between rice varieties and N sources were detected. Among the N treatments no significant difference on rice yield in *Sesbania rostrata* and urea treatments was found. The average rice yield of these treatments were 4,687 and 4,563 kg/ha, respectively. But rice yield obtained from the *Sesbania rostrata* was significantly higher than those of soybean residues plus urea, soybean residues alone and no N treatments which were of 4292, 4122 and 4168 kg/ha, respectively (Table 16). Incorporation of *Sesbania rostrata* increased rice yield by 12% comparing to no N fertilizer treatment.

Differences in grain yield due to the differences in growth characteristics reflected in numbers of panicles at maturity. The number of panicles per square-meter revealed significant effects of both rice varieties and N sources. The rice variety, RD7 significantly produced higher number of panicle per square-meter than KDML105 at $P<0.01$. The average number of panicle per square-meter of these two varieties were 220 and 199, respectively. Among the N sources treatments, *Sesbania rostrata* and urea treatments had significantly higher number of panicles per square-meter than those of no N fertilizer and soybean residues treatments (Table 17).

Table 16. Grain yield (kg/ha) of rice in different treatments

N-sources	Rice variety		Mean
	RD7	KDML105	
1. No N-fertilizer	4166	4170	4168
2. Urea at 50 kgN/ha	4598	4529	4563
3. Soybean residues at 1.25 t/ha	3986	4257	4122
4. Soybean residues at 1.25 t/ha + urea at 35 kgN/ha	4177	4473	4295
5. *Sesbania rostrata*	4598	4784	4687
Mean	4291	4443	

$LSD_{0.01}$ for N sources averaged over varieties = 445 kg/ha, no significant different between varieties

Besides the number of panicles per square-meter, the 1000-grain weight and the percentage of filled grain contribute to the rice grain yield. These two characteristics of yield components revealed significant differences between rice variety, but not among the N sources. The 1000-grain weight of RD7 was significantly higher than that of KDML105. The average 1000-grain weight of RD7 and KDML105 were 27.54 and 26.07 gm, respectively (Table 14). In contrast, KDML105 had significantly higher percentage of filled grain than RD7 (Table 18).

Table 17. The number of panicles per square-meter in different treatments

N-sources	Rice variety		Mean
	RD7	KDML105	
1. No N-fertilizer	198	186	192
2. Urea at 50 kgN/ha	237	204	220
3. Soybean residues at 1.25 t/ha	210	193	201
4. Soybean residues at 1.25 t/ha + urea at 35 kgN/ha	221	200	210
5. *Sesbania rostrata*	234	210	222
Mean	220	199	

$LSD_{0.01}$ for rice varieties = 17.6 panicles/m^2

$LSD_{0.05}$ for N sources = 20.3 panicles/m^2

Table 18. The 1000-grain weight (g) of rice in different treatments

N-sources	Rice variety		Mean
	RD7	KDML105	
1. No N-fertilizer	27.50	25.98	26.74
2. Urea at 50 kgN/ha	27.79	26.09	26.94
3. Soybean residues at 1.25 t/ha	27.32	26.55	26.93
4. Soybean residues at 1.25 t/ha + urea at 35 kgN/ha	27.27	25.80	26.53
5. *Sesbania rostrata*	27.81	25.93	26.87
Mean	27.54	26.07	

$LSD_{0.01}$ for rice variety = 0.68 g, no significant differences among N sources

Table 19. The percentage of filled grain of rice in different treatments

N-sources	Rice variety		Mean
	RD7	KDML105	
1. No N-fertilizer	67.8	76.1	71.5
2. Urea at 50 kgN/ha	71.4	77.7	74.6
3. Soybean residues at 1.25 t/ha	62.8	78.3	70.5
4. Soybean residues at 1.25 t/ha + urea at 35 kgN/ha	64.9	79.2	72.1
5. *Sesbania rostrata*	62.6	77.9	70.3
Mean	65.9	77.8	

$LSD_{0.01}$ for rice variety = 6.13%, no significant differences among N sources

Economic returns

Economic assessment of the treatment effects was estimated in terms of net return over total variable cost and marginal rate of return.

Net return over total variable cost (NRVC)

Since the yield obtained from the *Sesbania rostrata* and the urea treatment were significantly different from the others, the economic analysis will focus only on these two treatments. Eventhough their yield performance were not different statistically, net return of urea and *Sesbania rostrata* can substantially differ as price of relevant input factors vary. Based on the price prevailing in the study period, the net return over total variable cost (NRVC) of all treatments are presented in Table 20. That of *Sesbania rostrata* was the highest (7199 baht/ha) followed by that of urea (7065 baht/ha). The lowest NRVC was obtained from soybean residues treatment i.e. 6047 baht/ha.

Marginal rate of return (MRR)

The no N fertilizer treatment is used as the basis for calculation of MRR to investment of the improved technologies. The MRR of each treatment is defined as the incremental return as a percentage of the incremental cost.

Table 21 shows that the urea, the *Sesbania rostrata* and the soybean residues plus urea treatments gave the MRRs of 221%, 196% and 93%, respectively. Only the treatment with soybean alone resulted in the MRR of -161%.

Table 20. Total variable costs and return to individual treatments (B/ha)

Item	No N	Urea	Soybean residues	Soybean residues + urea	*S. rostrata*
1. *Sesbania rostrata* seed	-	-	-	-	300
					(3.24)
2. Land preparation cost of *Sesbania rostrata*	-	-	-	-	625
					(6.79)
3. Rice seed	220	220	220	220	220
	(2.65)	(2.47)	(2.62)	(2.51)	(2.39)
4. Land preparation for rice	1875	1875	1875	1875	1875
	(22.65)	(21.05)	(22.37)	(21.40)	(20.37)
5. Fertilizer	-	625	-	380	-
		(7.02)		(4.34)	
6. Transportation for soybean residues	-	-	100	100	-
			(1.19)	(1.14)	
7. Transportation cost	1250	1250	1250	1250	1250
	(15.10)	(14.04)	(14.92)	(14.27)	(13.58)
8. Chemical pesticide	1000	1000	1000	1000	1000
	(12.07)	(11.23)	(11.93)	(11.42)	(10.86)
9. Maintenance	940	940	940	940	940
	(11.35)	(10.56)	(11.22)	(10.73)	(10.21)
10. Harvesting	1250	1250	1250	1250	1250
	(15.10)	(14.64)	(14.92)	(14.27)	(13.08)
11. Threshing	500	500	500	500	500
	(6.04)	(5.61)	(5.97)	(5.71)	(5.44)
12. Transportation for rice	500	500	500	500	500
	(6.04)	(5.61)	(5.97)	(5.71)	(5.13)
13. Others	745	745	745	745	745
	(9.02)	(8.37)	(8.89)	(8.50)	(8.09)
Total variable costs	8280	8905	8380	8760	9205
Yield (kg/ha)	4168	4563	4122	4295	4687
Price of rice 3.5 (B/kg)					
Total return (B/ha)	14588	15970	14427	15032	16404
Net return over total variable cost (B/ha)	6308	7065	6047	6272	7199

Note: Figures in the parenthesis are the percentage of total variable cost

Table 21. Marginal rate of return in treatments with different N sources comparing to no N

N-sources	Total variable cost	Total return	Incremental return	Incremental cost	MRR (%)
	----------------	B/ha	----------------		
1. No N	8280	14588	-	-	-
2. Urea	8905	15970	1382	625	221
3. Soybean residues	8380	14427	-161	100	-161
4. Soybean residues + urea	8760	15032	444	480	93
5. Sesbania rostrata	9205	16404	1816	925	196

Sensitivity analysis

The sensitivity analysis revealed that if the price of urea and the cost of land preparation for *Sesbania rostrata* increase, the MRRS of these treatments will decline (Table 22). The MRR of *Sesbania rostrata* treatment will outperform than that of the urea treatment when the price of urea increases to 6 baht/kg or higher while the land preparation cost of *Sesbania rostrata* is hold at 625 baht/ha. When the cost of land preparation rises by 50% to 937.5 baht/ha, *Sesbania rostrata* can provide higher MRRs only if the price of urea are as high as 8 and 9 baht/kg. When cost of land preparation doubles or at 1250 baht/ha, *Sesbania rostrata* becomes less preferable at any price of urea. The maximum MRRs obtained from the two treatments (at various cost combinations) are shown in Table 23.

Table 22. Marginal rates of return of individual treatments comparing to no N at different prices of urea and different costs of land preparation for *Sesbania rostrata*

N-sources		Price of urea (B/ha)				
		5	6	7	8	9
		MRR(%)				
1. No N		-	-	-	-	-
2. Urea		221	184	156	138	122
3. Soybean residues		-161	-161	-161	-161	-161
4. Soybean residues + urea		93	80	70	63	57
5. *Sesbania rostrata*	(625)	196	196	196	196	196
	(937.5)	147	147	147	147	147
	(1250)	117	117	117	117	117

Note: The figures in parenthesis are the cost of land preparation for *Sesbania rostrata* (B/ha)

Table 23. Maximum marginal rates of return treatments at different costs of land preparation and urea

Price of urea (B/kg)	Cost of land preparation for *S.rostrata*		
	625	937.5	1250
	B/ha		
5	Urea	Urea	Urea
6	*S.rostrata*	Urea	Urea
7	*S.rostrata*	Urea	Urea
8	*S.rostrata*	*S.rostrata*	Urea
9	*S.rostrata*	*S.rostrata*	Urea

Changes in soil properties

Soil analysis suggested that pH, the percentage of organic matter, total nitrogen, available phosphorus and exchangeable potassium in soil after harvest were not significantly different among rice varieties and N source treatments (Table 24).

Table 24. Soil analyses results before and after harvest

N-sources	pH		%OM		%N		available P (ppm)		exchangeable K (ppm)	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Before	5.8	6.3	0.79	0.36	0.044	0.022	77	35	35	29
After										
1. No-N	4.9	5.7	0.99	0.49	0.051	0.025	66	50	17	23
2. Urea	5.0	6.0	1.00	0.49	0.050	0.025	61	55	18	22
3. SBR	4.9	6.0	1.03	0.53	0.051	0.027	66	61	19	22
4. SBR + urea	5.0	5.9	1.06	0.55	0.053	0.028	66	52	18	25
5. S. restrata	5.2	6.0	1.05	0.52	0.052	0.027	75	55	16	21
Mean	5.0	5.9	1.03	0.52	0.051	0.026	67	55	18	23