CHAPTER 6

NITROGEN DYNAMICS EXPERIMENT RESULT

6.1. Shoot dry weight of Chinat rice variety

Nutrient management had significant effect on shoot dry weight of Chinat rice variety at 15 days after flowering and dry weight of straw and stubble at harvest but did not had any effects on dry matter of shoot at panicle initiation, flowering stages and weight of panicles at harvest (Table 33)

Table 33. Analysis of variance of shoots dry weight of Chinat variety in different growth stages and weight of panicle, straw and stubble at harvest

Source of Variation	df	Panicle initiation	Flowering	15 days after flowering	At harvest		
					Panicle	Straw	Stubble
Treatment (A)	3	ns	ns	*	ns	*	*
Replication (B)	2	ns	ns	ns	ns	ns	*
CV %	6	26.34	24.79	28.89	15.27	22.23	31.52

* significant effects at 0.05 % level

no significant (ns)

Incorporation of *S. rostrata* either alone or combination with urea top dressing resulted in at least 30% shoot dry weight improvement compared to that of the control (Table 34). At 15 days after flowering stage the effect of *S. rostrata* incorporation on shoot biomass was clearly observed. *S. rostrata* incorporation produced about 85% more shoot biomass of Chinat rice variety than the control ($P \leq 0.05$). Top dressing of urea at the rate of 62.5 kg ha^{-1} after *S. rostrata* incorporation resulted in about 43% shoot dry weight improvement and there was no significant different between this treatment and the control or *S. rostrata* incorporation without top dressing of urea fertilizer. The application of chemical fertilizer resulted in about 13-27% shoot dry weight improvement of Chinat rice variety and the control was not found for all stages of rice growth. At harvest the *S. rostrata* incorporated treatments produced about 32-35% improvement of panicle weight while chemical fertilizer applied treatment produced only 11% improvement as compared with the control. However the significant effect of *S. rostrata* incorporation and chemical fertilizer treatments and on panicle dry weight at harvest were not found. There were no significant different between the two *S. rostrata* incorporated treatments and both produced significantly more straw and stubble dry weight at harvest than the control. The chemical fertilizer applied treatment increased about 11% dry weight of straw and about 26% dry weight of stubble over the control but this treatment did not differ from the control significantly.

Table 34. Effect of nutrient management on shoot dry weight of Chinat rice variety in different growth stage (g/m^2)

Nutrient management	Shoot dry weight (kg/m^2)					
	PI	F	15 DAF	HV		
				Panicle	Straw	Stubble
Control	0.55	0.74	0.83 b	0.37	0.27 b	0.38 c
S. rostrata	0.75 (36%)	1.17 (58%)	1.54 (85%) a	0.50 (35%)	0.43 (59%) a	0.64 (68%) ab
(16-20-0) + (46-0-0)	0.62 (13%)	0.94 (27%)	1.02 (23%) b	0.41 (11%)	0.30 (11%) b	0.48 (26%) bc
S. rostrata + (46-0-0)	0.74 (36%)	1.03 (39%)	1.19 (43%) ab	0.49 (32%)	0.41 (52%) a	0.67 (76%) a
LSD (0.05)	-	-	0.42	-	0.08	0.18
	ns	ns	s	ns	s	s

PI = Panicle initiation stage
F = Flowering stage
15 DAF = 15 days after flowering stage
HV = Harvesting stage

6.2. N content and N uptake of Chinat rice variety

The nutrient management had no significant effects on %N of shoot dry weight at all stages of growth (Table 35). Anyhow, rice plants from *S. rostrata* incorporated plot and chemical fertilizer applied seemed to have higher percentage of N than that from the control plot (Table 36).

Table 35. Analysis of variance of % N content of Chinat variety in different growth stage

Source of Variation	df	Panicle initiation	Flowering	15 days after flowering	At harvest		
					Panicle	Straw	Stubble
Treatment (A)	3	ns	ns	ns	ns	ns	ns
Replication (B)	2	*	ns	ns	ns	ns	ns
CV %	6	19.42	12.39	14.42	6.04	10.86	13.45

* indicates significant at 0.01 % level

ns indicates not significant

Table 36. % N of Chinat rice variety in different growth stage

Nutrient management	% N					
	PI	F	15 DAF	HV		
				Panicle	Straw	Stubble
Control	0.97	0.70	0.68	1.03	0.53	0.44
S. rostrata	1.06 (9%)	0.78 (11%)	0.77 (13%)	1.04 (1%)	0.56 (6%)	0.50 (14%)
(16-20-0) + (46-0-0)	1.12 (15%)	0.74 (6%)	0.71 (4%)	1.05 (2%)	0.58 (9%)	0.45 (2%)
S. rostrata + (46-0-0)	1.12 (8%)	0.84 (20%)	0.77 (13%)	1.09 (6%)	0.60 (13%)	0.56 (27%)
Mean	1.07	0.76	0.73	1.05	0.57	0.49
	ns	ns	ns	ns	ns	ns

PI = Panicle initiation stage
F = Flowering stage
15 DAF = 15 days after flowering stage
HV = Harvest stage

The significant effects of nutrient management on N uptake of Chianat rice variety at different growth stages were not observed also excepted that at 15 days after flowering stage (Table 37).

Table 37. Analysis of variance of N uptake of Chinat variety in different growth stage

Source of Variation	df	Panicle initiation	Flowering	15 days after flowering	At harvest		
					Panicle	Straw	Stubble
Treatment (A)	3	ns	ns	*	ns	ns	ns
Replication (B)	2	ns	ns	ns	ns	ns	ns
CV %	6	32.15	32.96	31.83	17.25	28.49	44.40

* indicates significant at 0.01 % level

ns indicates not significant

Nevertheless, incorporation of *S. rostrata* resulted in at least 50% more N uptake of rice than the control during PI to 15 DAF stages while the chemical fertilizer application increased N uptake about 29-30% over the control. At 15 day after flowering, the beneficial effects of *S. rostrata* incorporation on N uptake were clearly observed. About 107% more N uptake of rice shoot from the *S. rostrata* incorporated treatment and about 60% from the *S. rostrata* incombination with urea top dressing were observed in comparison with that of the control treatment ($P \leq 0.05$). In the chemical fertilizer applied plot, the rice plant contained about 30% more N uptake than that of the control but the difference was not significant. None of significant effect of the nutrient management on N uptake of panicle straw and stubble of rice a harvest were observed. Anyhow, more N uptake by rice about 36-38% in the panicle, 68-72% in the straw and 89-123% in stubble than those of the control were observed in rice plants from *S. rostrata* incorporated plots (Table 38).

Table 38. Effect of nutrient management on N uptake of Chinat rice variety in different growth stage (gN/m^2)

Nutrient management	N uptake (kgN/ha)					
	PI	F	15 DAF	HV		
				Panicle	Straw	Stubble
Control	5.26	5.17	5.65 c	3.82	1.45	1.69
S. rostrata	7.90 (50%)	9.13 (76%)	11.74 (107%) a	5.19 (36%)	2.43 (68%)	3.20 (89%)
(16-20-0) + (46-0-0)	6.80 (29%)	6.87 (33%)	7.33 (30%) b	4.40 (15%)	1.90 (31%)	2.23 (32%)
S. rostrata + (46-0-0)	8.45 (61%)	8.93 (73%)	9.05 (60%) b	5.28 (38%)	2.49 (72%)	3.77 (123%)
LDS (0.05)	-	-	2.86	-	-	-
	ns	ns	s	ns	ns	ns

PI = Panicle initiation stage
F = Flowering stage
15 DAF = 15 days after flowering stage
HV = Harvesting stage

6.3. Grain yield of Chinat rice variety

The beneficial effect of *S. rostrata* incorporation on grain yield of chinat rice variety were also observed (Table 39). In the control plot, about 4 t ha^{-1} total seed and about 3.8 t ha^{-1} of good seed yield were obtained. *S. rostrata* incorporation resulted in 43% (5.8 t ha^{-1}) and 23% (4.69 t ha^{-1}) improvement of total seed yield and total good seed yield of chinat rice variety respectively ($P \leq 0.05$) compared to the control. The additional N application as urea to *S. rostrata* incorporated plot did not produce significant more yield than *S. rostrata* incorporation alone. Anyhow, this treatment produced about 63% more total seed and about 36% good seed yield than the control. The application of chemical fertilizer did not have significant effect on total seed yield compared to the control but this treatment increased about 16% good seed yield over that of the control ($P \leq 0.05$). No significant effects of nutrient management on the weight of 1000 grain of chinat rice were observed.

Table 39. Effect of nutrient management on yield characteristics of Chinat rice variety

Nutrient management	Total seed yield (t ha^{-1})	Total good seed yield (t ha^{-1})	1000 grain weight (g)
Control	4.04 ^{b}	3.82 ^{c}	28.32
S. rostrata	5.77 $^{(43\%)\ a}$	4.69 $^{(23\%)\ ab}$	28.69 $^{(1\%)}$
(16-20-0) + (46-0-0)	4.37 $^{(8\%)\ b}$	4.44 $^{(16\%)\ b}$	29.16 $^{(3\%)}$
S. rostrata + (46-0-0)	6.58 $^{(63\%)\ a}$	5.20 $^{(36\%)\ a}$	29.09 $^{(3\%)}$
LSD (0.05)	1.22	0.61	-
	s	s	ns

6.4. Nitrogen dynamics in lowland rice system as affect by nutrient management practices.

The data from study on N dynamics in the soil indicated that N lost by leaching and runoff occurred in all nutrient management systems at all stages of rice growth and the type of N lost was the main cause of N lost. N lost due to algae activities (immobilization and NH_3 volatilization) was found also in each nutrient management system particularly at the early growth stage. However at the later stages in which the rice plants had denser plant canopy, such N lost was minimized or disappeared (Table 42).

6.4.1. Panicle initiation stage

At panicle initiation stage (PI) (Figure 6), the following amount (mgN/100g soil) N lost by leaching and runoff were estimated, 2.2 in the control treatment, 2.88 in *S. rostrata* incorporated treatment, 2.52 in the chemical fertilizer applied treatment and 3.42 in the *S. rostrata* + chemical fertilizer treatment. Actually at PI stage, urea had not been applied as top dressing to *S. rostrata* + chemical fertilizer treatment. Therefore the two *S. rostrata* incorporated treatments were similar. However, more N lost by runoff and leaching and by algae activities was observed in *S. rostrata* + chemical fertilizer treatment than the one with out N- fertilizer addition. No explanation could be made for such result but the variation of the soils might be one reason. The control plot, rice plants had the lowest dry weight of shoot (Table 33), it was possible that photosynthetic activity of algae in control plots might be high. The N lost due to algae activities was therefore observed in the control plot. At this stage, N lost thought crop removal ranged from 0.31-0.53 mgN/100 g soils. The highest value of N taken up by crops was found in *S. rostrata* incorporated with out N addition treatment. Anyhow, the apparent N uptake at this growth stage estimated from N dynamic study did not agree with the actual N uptake (Table 41)

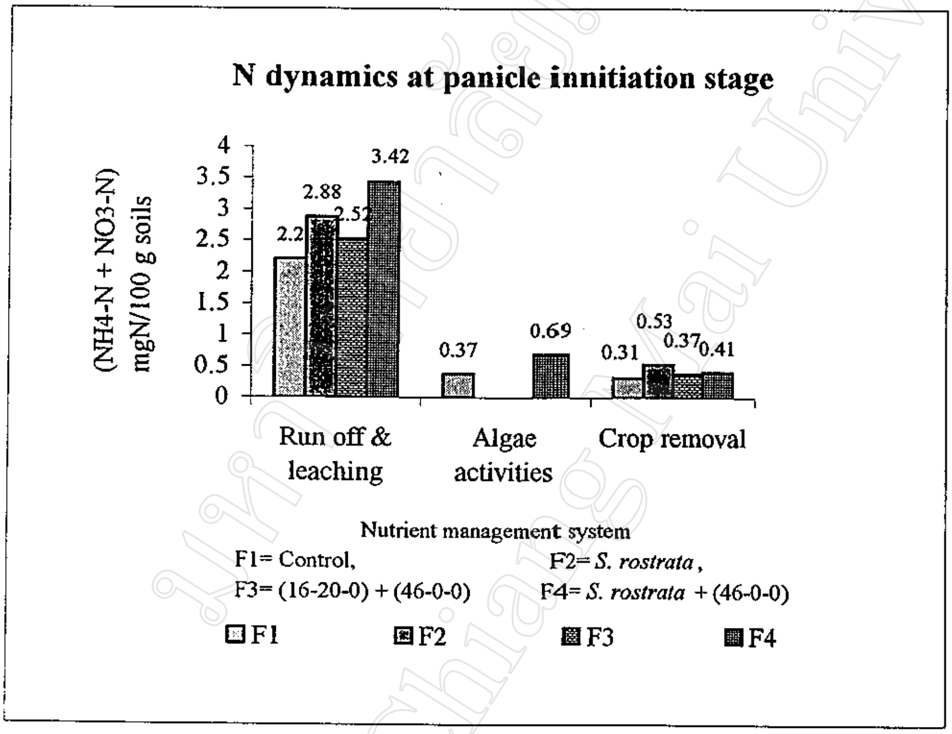

Figure 6: Nitrogen dynamics at panicle initiation stage

6.4.2 Flowering stage

At flowering stage (Figure 7), the estimated mount of N lost from leaching and runoff ranged from 3.14-5.51 mgN/100 g soil. The lowest value was found in *S. rostrata* incorporated with out N treatment and high value was obtained from *S. rostrata* plus chemical fertilizer. N lost through algae activities about 0.77 mgN/100 g soil was still observed in the chemical fertilizer applied plot. At this stage of growth, urea fertilizer had been applied as top dressing to the chemical fertilizer applied plot and *S. rostrata* incorporated + chemical fertilizer plots. Anyhow, the soil in the metal frame with plastic cover (B soil) could not receiving additional N fertilizer from top dressing. The estimation of N lost through algae activities by using the different between inorganic N contents of A soil and B soil might be therefore lower than the actual value. Nevertheless, the lost of N from algae activities at least 0.77 mgN/100 g soil occurred in the chemical fertilizer applied plot indicating that at this stage of growth, algal still had influenced on availability of N in this soil. The estimated values of N removed by crop ranged from 0.02-0.35 mgN/100 g soil. The estimated N removal by crop at this stage did not correspond to the among of N which was actually absorbed by rice plant (Table 9). This might be caused by the high rate of N-loss from A soil as compared with the rate of N-absorption by rice plant. Since top dressing of urea fertilizer was done by broadcasting to the rice field, it was therefore possible that A soil might receive less N during fertilizer broadcasting than D soil. This might be also the reason why the low values of estimated N lost by crop removal were obtained.

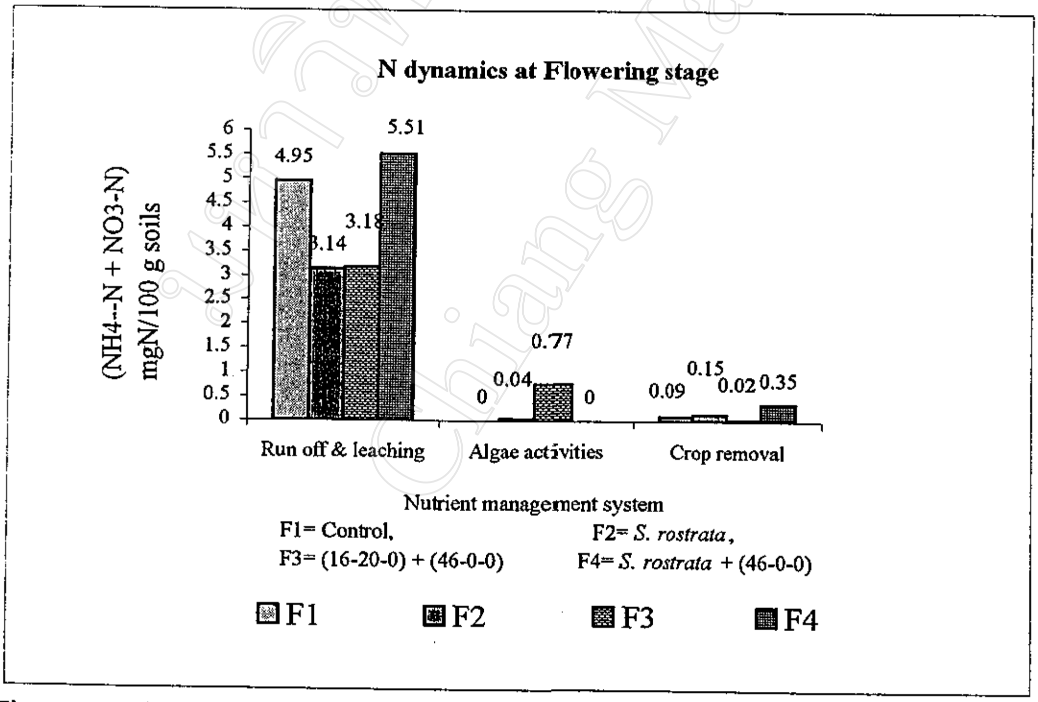

Figure 7: Nitrogen dynamics at flowering stage

6.4.3 15 days after flowering stage

At 15 days after flowering stage (15 DAF) (Figure 8), the estimated N lost by leaching and run off ranged from 2.84 to 5.79 mgN/100 g soil were obtained. The highest values of this type of N lost were found in *S. rostrata* incorporated treatment and the lowest value was obtained from the chemical fertilizer applied plots. N lost due to algal activities ranging from 0-0.4 mgN/100 g soil were obtained. Low values of N lost by algae activities were observed in the plots with top dressing of urea fertilizer. Since it was possible that the B soil in the covered metal frame might receive less N than A soil therefore the values of N lost by algal activities were under estimated. The N lost by crop removal at 15 DAF stage rang from 0.12-0.89 mgN/100 g soil which did not correspond to the actual N uptake (Table 41)

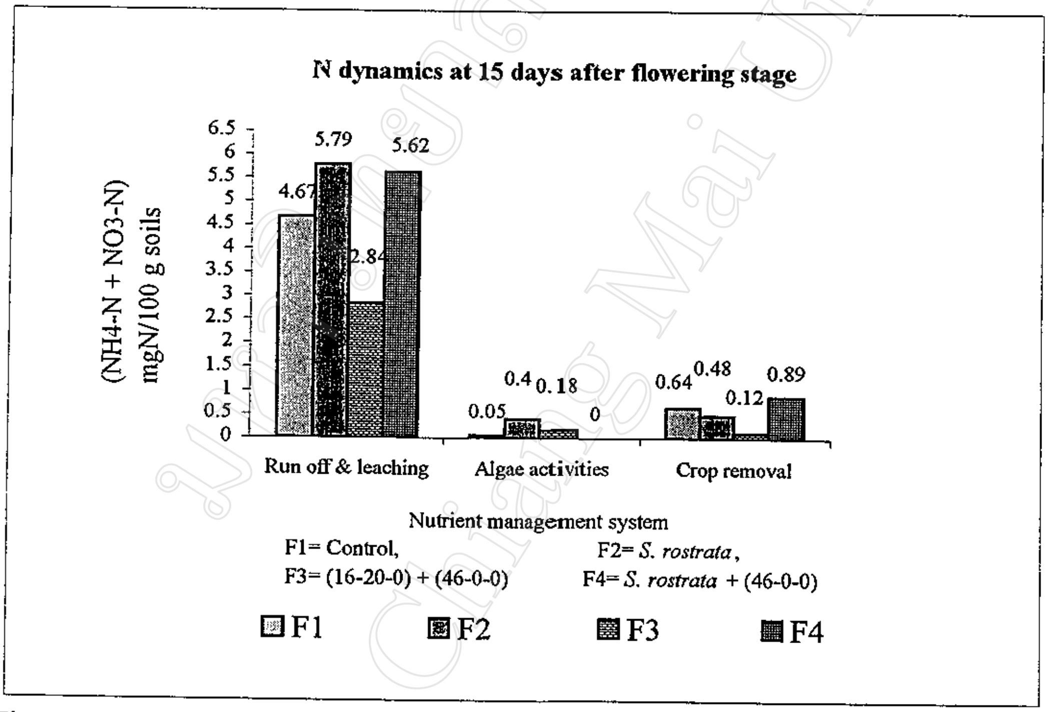

Figure 8: Nitrogen dynamics at 15 days after flowering stage

6.4.4 Harvesting stage

At harvest (Figure 9), N lost through run off and leaching ranging from 3.92-5.72 mgN/100 g soil were estimated. The lowest value was found in the control plots. None of N lost due to algal activity were found at this stage. The amount of N removed by crop ranged from 0.31-0.91 mgN/100g, which did not correspond to the actual N taken up by rice plants. Anyhow, the estimated N uptake value of *S. rostrata* incorporated treatment were about 50% of that from the control, which showed the similar trend as those from the actual amount of N taken up by rice plants.

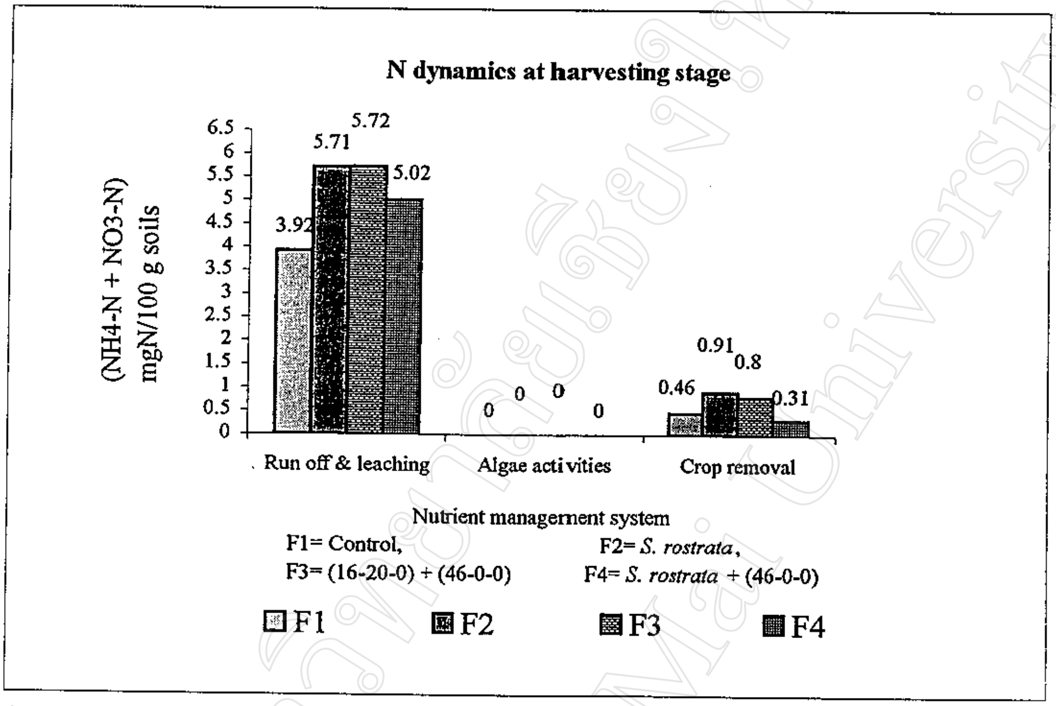

Figure 9: Nitrogen dynamics at harvest stage

Table 40. Total inorganic N in each growth stage of Chinat rice variety in different nutrient management system

Treatment	Total inorganic N (mgN/100g)				N increased (mgN/100 g)				N increased (kgN/ha)			
	PI	F	15 DAF	HV	PI	F	15 DAF	HV	PI	F	15 DAF	HV
F1	2.27	3.12	4.44	4.96								
F2	3.61	4.28	6.40	7.01	1.34	1.16	1.96	2.05	26.13	22.62	38.28	39.98
F3	2.83	5.21	5.41	7.84	0.56	2.09	0.97	2.88	1892	40.76	18.92	56.16
F4	5.32	6.14	6.59	6.71	1.45	3.02	2.15	1.75	28.28	58.89	41.93	34.13

Table 41. Apparent and actual N uptake by Chinat rice variety at different stage of growth

Treatment	Apparent N uptake (kgN/ha)				Actual N uptake (kgN/ha)			
	PI	F	15 DAF	HV	PI	F	15 DAF	HV
F1	6.05	1.76	12.48	8.97	52.60	51.70	56.50	69.60
F2	10.34	2.93	9.36	17.76	79.00	91.30	117.40	108.20
F3	7.22	0.39	1.56	15.60	68.00	68.70	73.30	85.30
F4	8.00	6.83	17.34	6.05	84.50	89.30	90.50	115.40

PI = Panicle initiation stage
F = Flowering stage
15 DAF = 15 days after flowering stage
HV = Harvest stage

Table 42. Nitrogen dynamics in lowland rice (Chinat variety), which received different nutrient management system in each growth stage of rice

Treatment		PI				FL				15 DAF				HV			
		NH4-N	NO3-N	TT	Delta N	NH4-N	NO3-N	TT	Delta N	NH4-N	NO3-N	TT	Delta N	NH4-N	NO3-N	TT	Delta N
F1	C soil	3.29	0.88	3.87		5.75	0.32	6.07		5.3	1.02	6.32		5.03	0.25	5.28	
	B soil	1.52	0.15	1.67	2.2*	1.01	0.11	1.12	4.95*	0.41	1.24	1.65	4.67*	1.1	0.26	1.36	3.92*
	A soil	1	0.3	1.3	0.37**	1.07	0.07	1.14	+	4.25	0.35	1.6	0.05**	1.57	0.25	1.83	+
	D soil	0.66	0.33	0.99	0.31***	1	0.04	1.05	0.09***	0.21	0.77	0.98	0.64***	1.16	0.21	1.27	0.46***
F2	C soil	3.31	0.31	3.61		4.19	0.09	4.28		4.82	1.58	6.4		6.4	0.21	7.01	
	B soil	0.72	0.02	0.74	2.88*	1.11	0.03	1.14	3.14*	0.48	1.13	1.61	5.79*	1.12	0.16	1.28	5.71*
	A soil	0.77	0.36	1.13	+	1.04	0.06	1.1	0.04**	0.44	0.77	1.21	0.4**	1.35	0.29	1.64	+
	D soil	0.39	0.21	0.6	0.53***	0.95	0	0.95	0.15***	0.23	0.5	0.73	0.48***	0.69	0.04	0.73	0.91***
F3	C soil	2.83	0	2.83		5.15	0.07	5.21		3.48	0.24	3.72		7.71	0.13	7.84	
	B soil	1.18	0	1.18	2.52*	1.99	0.04	2.03	3.18*	0.68	0.2	0.88	2.84*	1.98	0.13	2.12	5.72*
	A soil	0.98	0.25	1.23	+	1.22	0.04	1.26	0.77**	0.51	0.19	0.7	0.18**	2.25	0.22	2.47	+
	D soil	0.84	0.02	0.86	0.37***	1.1	0.14	1.24	0.02***	0.47	0.15	0.62	0.12***	1.56	0.11	1.67	0.8***
F4	C soil	3.48	1.83	5.32		5.97	0.17	6.14		4.63	0.27	6.59		6.5	0.21	6.71	
	B soil	1.77	0.13	1.9	3.42*	1.16	1	1.26	5.15*	0.73	0.3	0.97	5.62*	1.48	0.21	1.69	5.02*
	A soil	1.08	0.13	1.21	0.69**	1.52	0.05	1.57	+	1.07	0.31	1.38	+	1.5	0.22	1.72	+
	D soil	0.8	0	0.8	0.41***	1.16	0.06	1.22	0.35***	2.19	0.31	0.49	0.89***	1.29	0.12	1.41	0.31***

* = N lost (mgN/100 g soil) by leaching and run off ** = N lost (mgN/100 g soil) by algal activities *** = N lost (mgN/100 g soil) by crop removal
+ = No N lost by algal activities was found F1= Control F2 = *S. rostrata* F3 = (16-20-0) + (46-0-0) F4 = *S. rostrata* + (46-0-0)

6.5. Nitrogen mineralization of *S. rostrata*

There were no significant different of percentage of N released from *S. rostrata* among the four representative rice soil in the Chiang Mai lowlands during one-week incubation period. Anyhow, in the light texture soils (San Sai and MCC soils) more N were mineralized from *S. rostrata* than the heavy soils at 14 days after incubation, about 42% of total N from *S. rostrata* were released in MCC soil. In Sankampang soil, the N released from *S. rostrata* was 36% which was not different from MCC soil significantly. In San Sai and Mae Tang soils, about 29% of % total N from *S. rostrata* were obtained which did not differ significantly from Sankampang soil. At 28 days after incubation, only data from Sankampang and Mae Tang soils were available for statistical analysis. There tow soils were not differ significantly from each other anf the N released from S. rostrata were about 93% for Sankampang soil and about 65% for Mae Tang (Table 43).

Table 43. Percentage of N released from *S. rostrata* in different soils

Site	Incubation time (Days)				
	2	4	7	14	28
San Sai	1.55	13.25	18.38	29.71	-
Sankampang	1.90	3.40	3.55	35.86	92.74
Mae Tang	3.90	3.75	4.80	29.36	64.93
MCC	2.00	7.80	11.68	42.22	-
	ns	ns	ns	*	

Discussion

The effectiveness of *S. rostrata* to improve shoots dry weight and N uptake of Chinat rice variety was found on this study. Result of this experiment showed that at 15 days after flowering Chinat rice variety grown under different management practices had resulted in significant response in shoot dry weight and among of N uptake. Each of nutrient management practices gave higher shoot dry weight and among of N uptake than control. The greatest shoot dry weight and N uptake were found in *S. rostrata* treatment. As point out by Centeno et al. (1985), Furoc and Morris (1989), Morris et al. (1988) and Mulongoy (1986), rice grain yield, total dry matter yield, N uptake and productive tillers of rice in the Philippines were markly affected by *S. aculeate*, *S. cannabina*, and *S. rostrata* green manures. In this study, total seed yield, total good seed yield of Chinat rice variety increased significantly when fertilized, *S. rostrata* green manure was incorporated into the soil.

The study on nitrogen dynamics found that N lost in lowland rice system was occurred at all stages of rice growth in all nutrient management practices. The main activity that cause N lost was leaching and run off which rang from 3.92-5.27 mgN/100 g soil. Yatazawa (1977) estimated that 20kgN/ha is lost annually by leaching from rice paddies by leaching. Signh (1978) found run off losses as high as 5.6 kgN/ha from irrigated rice field in the Philippines.

Algae play an important role in immobilizing nitrogen from broadcast fertilizer application (Mitsui 1954, Craswell *et al.,* 1979). In this study, N lost due to algal activities was also found in each nutrient management system particularly at the early growth stage. According to the work of Vlek and Craswell (1978) up to 30% of added N can be absorbed by algae. DeDatta (1981) reported that loss of added N by NH_3 volatilization in lowland rice soils rang fro, 5-47% while loss by denitrification rang from 28-33%. Watanabe et al. (1981) reported the work on ammonia volatilization and reported that extensive losses, 0.3 to 30% of added nitrogen through this mechanism. In this study, the highest N lost by algae activities was observed in Chemical fertilizer treatment at 15 days after flowering stage, which was 0.4 mgN/100 g soil. This study can not measure among of N which can be lost by denitrification, however, the data showed that NO^-_3 occurred at all stages of rice growth in all nutrient management practices (Table 42). Of this it was assumed that N lost was also occurred by denitrification.

A major source of N for paddy rice is the mineralization of soil organic matter form. It this study, nitrogen mineralization from added *S. rostrata* as green manure in different soil sample was monitored by incubation method. Ammonium-N release from S. rostrata started immediately and increased slightly within 2-28 days. At 14 days after incubation, significant difference in NH^+_4-N release was observed among the different soil type. The greatest was observed in MCC soil which 42.22% N released. This result was similar to that reported by other workers Bryan (1991) for instance, report that Ammonium-N accumulation following incorporation of the *S. rostrata* green manure started immediately and reached a steady state within 10-31 days. Therefore, immediate transplanting of rice following plough down of *S. rostrata* green manure is important, not only because it fits into the Chiang Mai lowland rice system, but because the release of NH^{+}_{4}-N begins immediately and so, too, can volatilization and lost by any processes.