CHAPTER 5

RESULT OF ON STATION EXPERIMENT

5.1. Climatic and edaphic conditions

Results of the soil analysis indicated that soil had pH of 5.45, organic matter of 1.18 %, Nitrogen of 0.062 %, Phosphorus of 106.83 ppm, and Potassium of 21.04 ppm. Temperature during the period of the study varied from 20.26 to 32.52°C. Solar radiation varied 14.30 to 21.52 MJ/m^2, and total rainfall was 1604.10 mm with the peak in September (393.20 mm).

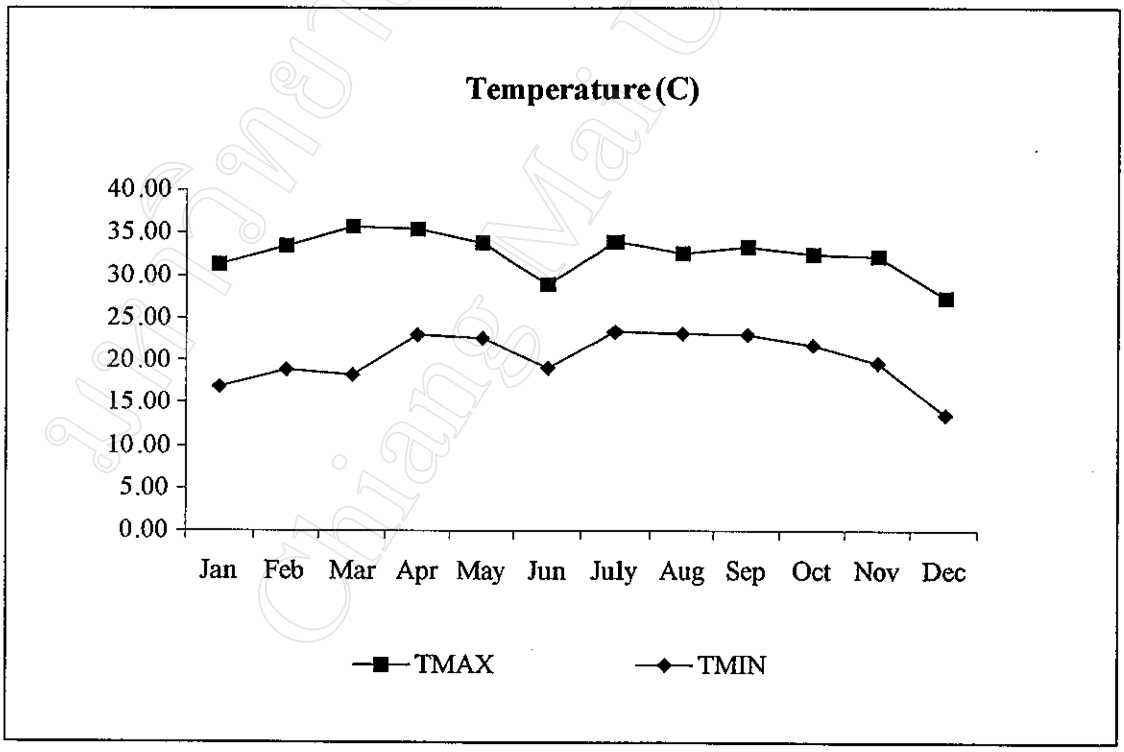

Figure 4. Maximum and minimum temperature (°C) Jan-Dec 1999.

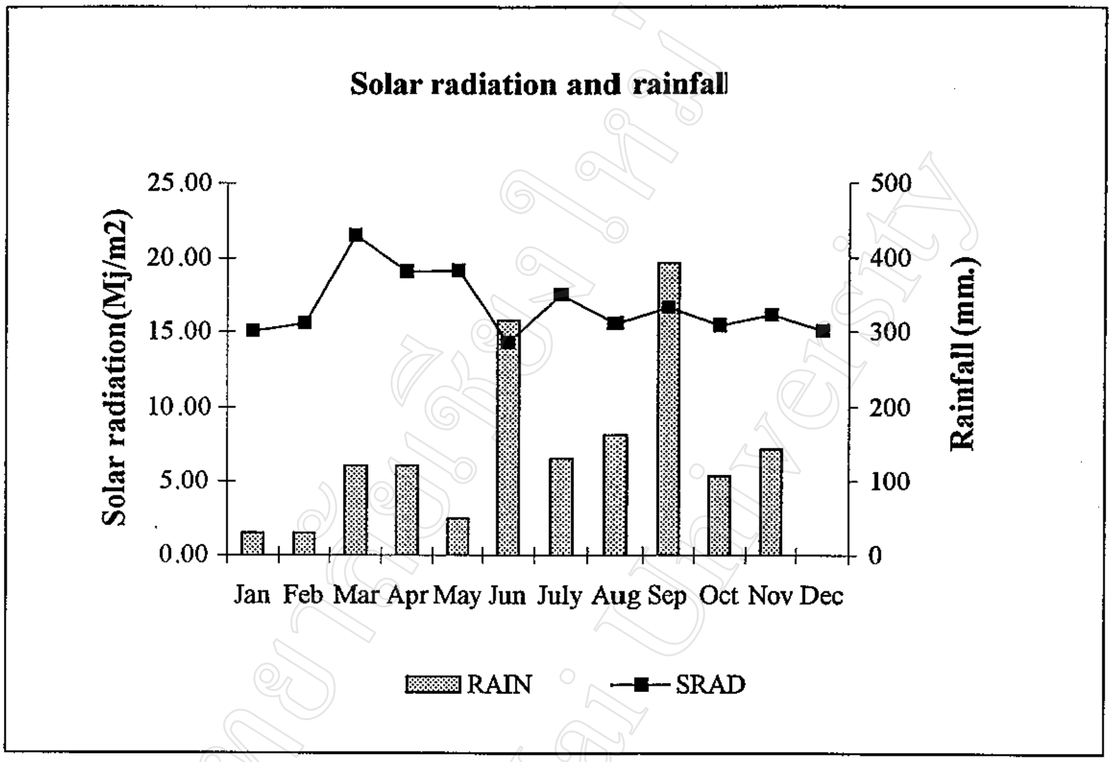

Figure 5. Solar radiation (MJ/m^2) and rainfall (mm) during Jan to Dec 1999 at the Irrigated Research Station of Multiple Cropping Center

5.2. *Sesbania rostrata*

Sesbania rostrata was planted on 11th May 1999. It was plowed into the soil on 6th July 1999. Above ground dry biomass and N content of *Sesbania* were measured before the incorporation. The weights of dry matter of *Sesbania* samples ranged from 2.6 to 4.8 t ha^{-1}, with N content of 3.1%. Average N equivalent was 116.7 kg ha^{-1}. These results are summarized in Table 9

Table 9. Pre-rice *Sesbania rostrata* yields

Plot	Dry biomass (t/ha)	%N content	N equivalent (kg/ha)
A1F2	4.6	3.1	142.6
A1F4	4.0	3.1	124
A2F2	3.1	3.1	96.1
A2F4	2.6	3.1	80.6
B1F2	4.1	3.1	127.1
B1F4	4.1	3.1	127.1
B2F2	4.2	3.1	130.2
B2F4	2.9	3.1	89.9
C1F2	4.8	3.1	148.8
C1F4	4.4	3.1	136.4
C2F2	3.0	3.1	93
C2F4	3.6	3.1	111.6
Overall average	3.8	3.1	117.3
SD	0.7	-	22.5
CV %	0.2	-	0.2

5.3. Effects of nutrient managements on plant height and yield characteristics of selected varieties of glutinous and non glutinous rice.

Results of analysis of variance (Tables 10 & 11) indicated that there was a strong, significant effect of nutrient managements on total straw yield, total biomass yield, and height of both groups of rice varieties tested ($P \leq 0.01$). However, no significant effect of nutrient managements was found on total grain yield, total filled grain yield, percent filled grain, harvest index, panicles per square meters, tillers per square meters, percent productive tillers, and 1000 grains weight of rice.

It was also found that there were significant differences in, harvest index, total straw yield, height, panicles/m^2, tillers/m^2, and 1000 grains weight of tested varieties

($P \leq 0.01$). However, no significant differences were found with total grain yield, total biomass yield, total filled grain yield and percent productive tillers. Besides, significant differences between percent filled grain were also found among tested varieties ($P \leq 0.05$). Furthermore, there was a significant effect of an interaction between nutrients management and varieties on height and percent productive tiller ($P \leq 0.05$).

Table 10. Analysis of variance of yield characteristics of selected varieties of glutinous and non-glutinous rice.

Source of variation	Total straw yield (t ha^{-1})	Total grain yield (t ha^{-1})	Total biomass yield (t ha^{-1})	Total filled grain yield (t ha^{-1})	% filled grain	Harvest Index
Nutrient managements (A)	**	ns	**	ns	ns	ns
Replication (B)	ns	ns	ns	ns	ns	ns
Variety (C)	**	ns	ns	ns	*	**
A x C	ns	ns	ns	ns	ns	ns
C.V (%)	19.17	15.09	14.77	15.85	2.75	11.68

Table 11. Analysis of variance of plant height and yield characteristics of selected varieties of glutinous and non-glutinous rice.

Source of variation	Height (cm.)	Panicles /m^2	Tillers / m^2	% productive tillers	1000 grains weight (g)
Nutrient managements (A)	**	ns	ns	ns	ns
Replication (B)	ns	ns	ns	ns	ns
Variety (C)	**	**	**	ns	**
A x C	*	ns	ns	*	ns
C.V %	20.75	17.50	15.38	5.20	4.56

5.3.1. Total straw yield

Results of analysis of variance (Tables 10&11) showed that total straw yields of tested rice varieties were strongly affected by nutrient managements ($P \leq 0.01$). In general, applying fertilizer and incorporating of *S. rostrata* increased total straw yields (Table 12). On average, the highest total straw yield was recorded in *S. rostrata* + (46-0-0) treatment, which was 6.04 t ha^{-1}. In contrast, the lowest total straw yield was observed in Control treatment, which was 4.26 t ha^{-1}. Besides, *S. rostrata* incorporation and (16-20-0) + (46-0-0) application showed greater responses in total straw yield than the Control, which were 5.95 t ha^{-1} and 5.62 t ha^{-1}, respectively. Among the varieties tested, the highest total straw yield was observed with Sanphatong, while the lowest total straw yield was recorded with Chinat. Average grain yields of all varieties including: RD.6, Dangkornkaen, RD. 23, and Niew Ubol were 5.83 t ha^{-1}, 5.32 t ha^{-1}, 4.95 t ha^{-1}, and 5.16 t ha^{-1}, respectively (Table 13).

5.3.2. Total biomass yield

Results of analysis of variance indicated that there was strong significant effect of nutrient managements on total biomass yield ($P \leq 0.01$). The maximum average total biomass was observed in *S. rostrata* + (46-0-0) treatment, while the lowest average total biomass yield was recorded in Control treatment. Average total biomass yields of plots receiving *S. rostrata* and (16-20-0) + (46-0-0) were 10.05 t ha^{-1} and 10.17 t ha^{-1}, respectively (Table 12)

5.3.3. Percent filled-grain

Results of analysis of variance revealed that percent filled grain among varieties were significantly different ($P \leq 0.05$). The highest percent filled grain was observed with Niew Ubol, while the lowest percent filled grain was recorded with Sanphatong. Average percent filled grain (by weight) of all varieties including: RD. 6, Dangkornkaen, RD. 23 and Chinat were 96.8%, 95.4%, 95.7%, and 97.3%, respectively (Table 13).

5.3.4. Harvest index

Results of analysis of variance revealed that there were strong significant differences between harvest indices of the tested varieties ($P \leq 0.01$). The highest harvest index was observed with Chinat, while the lowest harvest index was recorded with Dangkornkaen. Average percent good seeds of all varieties including: RD. 6, RD. 23, Sanpathong and Niew Ubol were 0.40, 0.46, 0.39, and 0.43, respectively (Table 13).

5.3.5. Plant height

Results of analysis of variance (Table 11) showed that plant heights of all varieties grown under each nutrient management practice were very significantly different (P $\leq$ 0.01). The highest plant height was observed in the *S. rostrata* treatment, which was 139 cm., while the lowest plant height was recorded in the Control treatment, which was 123 cm. Average plant height of plots receiving *S. rostrata* + (46-0-0) and (16-20-0) + (46-0-0) were 138 cm. and 129 cm., respectively. Among the varieties tested, the highest plant height was observed with Sanphatong, which was 165.48 cm., while the lowest was recorded with Chinat, which was 101cm.. Average plant heights of all varieties including: RD.6, Dangkornkaen, Rd. 23, and Niew Ubol were 153 cm., 154 cm., 105 cm., and 115 cm., respectively (Table 13).

Analysis of variance also revealed that interactions between nutrient managements and varieties resulted in significant differences in plant heights (P $\leq$ 0.05). In general, it was clearly demonstrated that the use of *S. rostrata* as green manure increased plant heights of all varieties (Table 14). On average, the highest plant height in *S. rostrata* treatment was recorded with Sanphatong variety, which was 172 cm. In contrast, the lowest of plant height was observed with Chinat variety in the Control plot, which was 95 cm.

5.3.6. Panicles per square meter

Results of analysis of variance revealed that panicles per square meter among tested varieties were highly significantly different (P $\leq$ 0.01). The highest panicles per square meter were observed with Chinat, which was 218 panicles, while the lowest panicle per square meter was recorded with RD. 6, which was 172 panicles. The panicles per square meter of all varieties including: Dangkornkaen, RD. 23, Sanphatong and Niew Ubol were 187, 205, 137, and 182, respectively (Table 13).

5.3.7. Tillers per square meter

Results of analysis of variance revealed that tillers per square meter among varieties were very significantly different ($P \leq 0.01$). The highest tillers per square meter was observed with Chinat, which was 246 tillers, while the lowest tiller per square meter was recorded with Sanphatong, which was 165 tillers. The tillers per square meter of all varieties including: RD.6, Dangkornkaen, RD. 23, and Niew Ubol were 204, 218, 230, and 220, respectively (Table 13).

5.3.8. The 1000 grains weight

Results of analysis of variance revealed that 1000 grains weight among varieties were very significantly different ($P \leq 0.01$). The highest 1000 grains weight was observed with Chinat, which was 28.93 gram, while the lowest 1000 grains weight was recorded with Dangkornkaen, which was 25.92 gram. The 1000 grains weight of all varieties including: RD.6, RD. 23, Sanpathong, and Niew Ubol were 26.39 g, 27.03 g, 28.22 g, and 28.43 g, respectively (Table 13).

Table 12. Plant height and yield characteristics of selected varieties of glutinous and non glutinous rice as affected by nutrient managements.

Nutrient managements	Total straw yield (t ha^{-1})	Total biomass yield (t ha^{-1})	Height (cm.)
Control	4.26	7.70	123
S. rostrata	5.95	10.05	139
(16-20-0) + (46-0-0)	5.26	9.30	129
S. rostrata + (46-0-0)	6.04	10.17	138
LSD (0.05)	0.63	0.91	4.89

Table 13. Plant height and yield characteristics of selected varieties of glutinous and non glutinous rice as affected by nutrient management.

Varieties	Type	Total straw yield (t/ha)	% Filled grains	Harvest Index	Height (cm.)	Panicles /m^2	Tillers / m^2	1000 grains weight (g)
RD. 6	G	5.83	96.8	0.40	153	172	204	26.39
Dang-kornkaen	NG	5.32	95.4	0.38	154	187	218	25.92
RD. 23	NG	4.95	95.7	0.46	105	205	230	27.03
Sanpathong	G	6.14	94.7	0.39	165	137	165	28.22
Chinat	NG	4.89	97.3	0.47	101	218	247	28.93
Niew-Ubol	G	5.16	97.7	0.43	115	182	220	28.43
LSD (0.05)		0.52	1.9	0.03	4.34	26.85	24.82	0.80

G = Glutinuous
NG = non-glutinous

Table 14. Plant height (cm.) of glutinous and non glutinous rice as affected by Interaction between nutrient management and varieties.

Varieties	Control	*S. rostrata*	(16-20-0) + (46-0-0)	*S. rostrata* + (46-0-0)	Mean	SD
RD. 6	138.55	171.05	141.75	159.45	152.70	15.30
Dang-kornkaen	143.50	162.75	149.80	161.19	154.31	9.23
RD. 23	98.05	105.10	105.30	112.20	105.16	5.78
Sanpathong	154.65	172.20	165.00	170.05	165.48	7.82
Chinat	94.50	104.50	99.95	105.70	101.16	5.09
Niew-Ubol	110.30	118.05	113.25	116.40	114.50	3.44
Mean	123.26	138.94	129.18	137.50		
SD	25.53	33.08	26.63	28.98		
% Increased	0	12.72	4.80	11.55		

LSD interaction = 15.13

Table 15. Percent productive tillers of glutinous and non glutinous rice as affected by interaction between nutrient management and varieties.

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
RD. 6	86	83	84	86	85	2
Dang-kornkaen	86	85	90	82	86	3
RD. 23	92	90	88	86	89	3
Sanpathong	83	86	83	80	83	2
Chinat	87	88	90	88	88	1
Niew-Ubol	78	80	85	87	83	4
Mean	85	85	87	85		
SD	5	4	3	3		
% productive tiller increasing	0	0.00	2.35	0.00		

LSD interaction = 0.10

5.4. Effect of nutrient management on plant height and yield characteristics of selected quality rice varieties.

Results of analysis of variance (Tables 16 & 17) indicated that nutrient managements had significant effect on plant height ($P \leq 0.01$). Besides, significant differences of total straw yield and total biomass yield were also found ($P \leq 0.05$). Nevertheless, no significant effect of nutrient management was found with total grain yield, total filled grain yield, percent filled grain, harvest index, panicles per square meters, tillers per square meters, percent productive tillers, and 1000 grains weight of this group of rice varieties.

In addition, the results also revealed that there were significant differences in total grain yield, total filled grain yield, and panicles/m^2 ($P \leq 0.01$) of the tested varieties. Besides, significant differences of total biomass yield and percent productive tiller also found between varieties ($P \leq 0.05$). However, no significant differences found between total straw yield, percent filled grain, harvest index, tillers/m^2, and 1000 grains yield.

Table 16. Analysis of variance of yield characteristics of selected quality rice varieties.

Source of variation	Total straw yield (t ha^{-1})	Total grain yield (t ha^{-1})	Total biomass yield (t ha^{-1})	Total filled grain yield (t ha^{-1})	% filled grain	Harvest Index
Nutrient managements (A)	*	ns	*	ns	ns	ns
Replication (B)	ns	ns	ns	ns	ns	ns
Variety (C)	ns	**	*	**	ns	ns
A x C	ns	ns	ns	ns	ns	ns
C.V %	24.80	15.94	18.92	15.86	3.02	12.37

Table 17. Analysis of variance of plant height and yield characteristics of selected quality rice varieties.

Source of variation	Height (cm.)	Panicles /m^2	Tillers / m^2	Productive tillers (%)	1000 grains weight (g)
Nutrient managements (A)	**	ns	ns	ns	ns
Replication (B)	**	ns	ns	*	ns
Variety (C)	**	**	ns	*	ns
A x C	ns	ns	ns	ns	ns
C.V %	14.39	15.20	13.60	5.09	6.92

5.4.1. Total straw yield

Results of analysis of variance indicated that there were significant differences between total biomass yields ($P \leq 0.05$). The maximum average total straw yield was observed in *S. rostrata* + (46-0-0) treatment, which was 8.03 t ha^{-1}, while the lowest average total biomass yield was recorded in Control treatment, which was 4.79 t ha^{-1}. Average total straw yields of plots receiving *S. rostrata* and (16-20-0) + (46-0-0) were 6.56 t ha^{-1} and 5.90 t ha^{-1}, respectively (Table 18)

5.4.2. Total grain yield

Results of analysis of variance revealed that total grain yield among varieties were highly significantly different ($P \leq 0.01$), although they were not significantly different under the nutrient management practices. The highest total grain yield was observed with Pitsanuloke 60-2, which was 4.96 t ha^{-1}, while the lowest total grain yield was recorded with Pitsanuloke 60-1, which was 3.96 t ha^{-1}. Total grain yield of all varieties including: Chinat, KDML 105, RD. 15, and Dangmali were 4.85 t ha^{-1}, 4.08 t ha^{-1}, 4.08 t ha^{-1}, and 4.08 t ha^{-1}, respectively (Table 19).

5.4.3. Total biomass yield

Results of analysis of variance showed that there were significant differences between total biomass yields of varieties under each nutrient management practice ($P \leq 0.05$). The highest total biomass yield was observed in *S. rostrata* + (46-0-0) treatment, which was 12.77 t ha^{-1}. In contrast, the lowest total biomass yield was recorded in Control treatment, which was 8.54 t ha^{-1}. Average total biomass yields of *S. rostrata* and (16-20-0) + (46-0-0) treatment were 11.16 t ha^{-1} and 9.96 t ha^{-1}, respectively (Table 18).

Among the varieties tested, the highest total biomass yield was observed with Pitsanuloke 60-2, which was 11.86 t ha^{-1}, while the lowest was recorded with KDML 105, which was 9.99 t ha^{-1}. Average total biomass yields of all varieties: including Chinat, Pitsnuloke 60-1, RD.15, and Dangmali were 10.25 t ha^{-1}, 10.86 t ha^{-1}, 10.96 t ha^{-1}, and 10.0 t ha^{-1}, respectively (Table 19).

5.4.4. Total filled grain yield

Results of analysis of variance revealed that total filled grain yields among varieties were highly significantly different ($P \leq 0.01$). However, no significant differences were found under the nutrient management practices. The highest total filled grain yield was observed with Pitsanuluke 60-2, which was 4.64 t ha^{-1}, while the lowest total filled grain yield was recorded with KDML 105,which was 3.82 t ha^{-1}. Average total filled grain yields of all varieties: including Chinat, Pitsanuluke 60-1, RD.15, and Dangmali were 4.38 t ha^{-1}, 3.76 t ha^{-1}, 3.9 t ha^{-1}, and 3.90 t ha^{-1}, respectively (Table 19).

5.4.5. Plant height

Results of analysis of variance showed that there were strong significant differences between plant heights of all varieties under each nutrient management practice ($P \leq 0.01$). The highest plant height was observed in *S. rostrata* + (46-0-0) treatment, which was 136 cm. In contrast, the lowest plant height was recorded in Control treatment, which was 118 cm. Average plant heights of plots receiving *S. rostrata* and (16-20-0) + (46-0-0) were 132 cm., and 128 cm., respectively (Table 18).

Among the varieties tested, the highest plant height was recorded with KDML 105, which was 142 cm., while the lowest was observed with Chinat, which was 101.4 cm. Average plant heights of all varieties including: Pitsanuloke 60-1, RD. 15, Dangmali, and Pitsanuloke 60-2 were 142 cm., 139 cm., 137 cm., and 111 cm., respectively (Table 19).

5.4.6. Panicles per square meter

Results of analysis of variance showed that panicles/m^2 among varieties were significantly differences ($P \leq 0.05$). The highest panicles/m^2 was observed with Pitsanuloke 60-2, which was 223 panicles. In contrast, the lowest panicles/m^2 was recorded with Dangmali, which was 173 panicles. Average panicles/m^2 of all varieties including: Chinat, KDML 105, Pitsanuloke 60-1, and RD.15 were 223 panicles, 190 panicles, 188 panicles, and 180 panicles, respectively (Table 19).

5.4.7. Percent productive tillers

Results of analysis of variance showed that there were significant differences between percent productive tillers among tested varieties ($P \leq 0.05$). The highest percent productive tillers was observed with Pitsanuluke 60-2, which was 90%, while the lowest percent productive tillers recorded with Dangmali, which was 80%.

Average percent productive tillers of all varieties including: Chinat, KDML 105, Pitsanuloke 60-1, and Rd. 15 were 87%, 84%, 83% and 85%, respectively (Table 19).

Table 18. Plant height and yield characteristics of selected quality rice varieties as effected by nutrient managements.

Nutrient managements	Total straw yield ($t\ ha^{-1}$)	Total biomass yield ($t\ ha^{-1}$)	Height (cm.)
Control	4.79	8.54	118
S. rostrata	6.56	11.16	132
(16-20-0) + (46-0-0)	5.90	9.96	128
S. rostrata + (46-0-0)	8.03	12.77	136
LSD (0.05)	1.70	1.94	4.60

Table 19. Plant height and yield characteristics of selected quality rice varieties as effected by varieties.

Source of variation	Total grain yield ($t\ ha^{-1}$)	Total biomass yield ($t\ ha^{-1}$)	Total filled grain yield ($t\ ha^{-1}$)	Height (cm.)	Panicle $/m^2$	% productive tillers
Chinat	4.58	10.25	4.38	101	222	87
KDML 105	4.08	9.99	3.82	142	190	84
Pitsanuloke 60-1	3.96	10.86	3.76	141	188	83
RD. 15	4.08	10.69	3.98	139	180	85
Dangmali	4.08	10.02	3.90	136	173	80
Pitsanuloke 60-2	4.96	11.86	4.64	111	223	90
LSD (0.05)	0.40	1.10	0.45	7.8	19.9	5

5.5.Effect of nutrient management on plant height and yield characteristics of modern HYV rice

Results of analysis of variance (Tables 20 & 21) indicated that total grain yield, total biomass yield, total filled grain yield, and panicles per square meter of this group of rice varieties grown under each nutrient management practice were highly significantly different ($P \leq 0.01$). Significant differences were also found with total straw yield, plant height, and tillers per square meter ($P \leq 0.05$). However, no significant differences were found with percent filled grain, harvest index, percent productive tillers, and 1000 grains of rice.

The results also revealed that plant heights and 1000 grains of tested varieties were very significantly different ($P \leq 0.01$). In addition, significant differences of percent filled grain, harvest index, and percent productive tillers were also found between varieties ($P \leq 0.05$). However, no significant differences were found with total straw yield, total grain yield, total biomass yield, total filled grain yield, panicles and tillers per square meter between these varieties. Furthermore, significant differences that resulted from interactions between nutrient managements and varieties were found with total straw yield, total biomass, and harvest index ($P \leq 0.05$).

Table 20. Analysis of variance of yield characteristics of modern HYV rice.

Source of variation	Total straw yield (t ha^{-1})	Total grain yield (t ha^{-1})	Total biomass yield (t ha^{-1})	Total filled grain yield (t ha^{-1})	% filled grain	Harvest Index
Nutrient managements (A)	*	**	**	**	ns	ns
Replication (B)	ns	**	ns	**	ns	ns
Variety (C)	ns	ns	ns	ns	*	*
A x C	*	ns	*	ns	ns	*
C.V %	21.19	18.01	17.82	18.56	2.00	8.50

Table 21. Analysis of variance of plant height and yield characteristics of modern HYV rice.

Source of variation	Height (cm.)	Panicles /m^2	Tillers / m^2	% productive tillers	1000 grains weight (g)
Nutrient managements (A)	*	**	*	ns	ns
Replication (B)	*	ns	ns	ns	ns
Variety (C)	**	ns	ns	*	**
A x C	ns	ns	ns	ns	ns
C.V %	6.97	16.34	16.44	3.05	7.01

5.5.1. Total straw yield

Results of analysis of variance showed that straw yields of tested rice varieties were significantly different ($P \leq 0.05$). The highest total straw yield was observed in *S. rostrata* + (46-0-0) treatment, which was 5.73 t ha^{-1}, while the lowest total straw yield was recorded in Control treatment, which was 4.06 t ha^{-1}. Average total straw yield of plots receiving *S. rostrata* and (16-20-0) + (46-0-0) were 5.33 t ha^{-1} and 5.10 t ha^{-1}, respectively (Table 22).

In addition, significant differences that resulted from interactions between nutrient managements and varieties were found with total straw yields ($P \leq 0.05$). On average, the highest total straw yield of 6.28 t ha^{-1} was recorded with Suphanburi 1 which receiving *S. rostrata* treatment. In contrast, the lowest of total straw yield of 3.46 t ha^{-1} was observed with Suphanburi 2 variety in Control treatment (Table 24).

5.5.2. Total grain yield

Results of analysis of variance showed that total grain yields of tested varieties were very significantly different ($P \leq 0.01$). The highest total grain yield was observed in *S. rostrata* + (46-0-0) treatment, which was 5.59 t ha^{-1}, while the lowest total grain yield was recorded in Control treatment, which was 3.96 t ha^{-1}. Average total grain yield of plots receiving *S. rostrata* and (16-20-0) + (46-0-0) were 5.48 t ha^{-1} and 4.79 t ha^{-1}, respectively (Table 22).

5.5.3. Total biomass yield

Results of analysis of variance showed that total biomass yields of tested rice varieties were very significantly different ($P \leq 0.01$). The highest total biomass yield was observed in *S. rostrata* + (46-0-0) treatment, which was 11.32 t ha^{-1}, while the lowest total straw yield was recorded in Control treatment, which was 8.02 t ha^{-1}. Average total straw yields of plots receiving *S. rostrata* and (16-20-0) + (46-0-0) were 10.80 t ha^{-1} and 9.89 t ha^{-1}, respectively (Table 22)

In addition, significant differences that resulted from interactions between nutrient managements and varieties were found with total biomass yields ($P \leq 0.05$). On average, the highest total biomass yield of 12.89 t ha^{-1} was recorded with Suphanburi 1 which was grown in *S. rostrata* + (46-0-0) treatment. In contrast, the lowest of total biomass yield of 7.18 t ha^{-1} was observed with Suphanburi 60 variety in Control treatment (Table 25).

5.5.4. Total filled grain yield

Results of analysis of variance indicated that total filled grain yield of rice varieties grown under different nutrient managements were highly significantly different ($P \leq 0.01$). The highest total filled grain yield was observed in *S. rostrata* + (46-0-0) treatment, which was 5.36 t ha^{-1}, while the lowest total filled grain yield was recorded in Control treatment, which was 3.83 t ha^{-1}. Average total filled grain yield of plot receiving *S. rostrata* and (16-20-0) + (46-0-0) were 5.31 t ha^{-1} and 4.65 t ha^{-1}, respectively (Table 22).

5.5.5. Percent filled grain

Results of analysis of variance showed that there were significant differences between percent filled grains of tested varieties ($P \leq 0.05$). The highest percent filled grain was observed with Chinat and Suphanburi 90, which was 98%, while the lowest percent filled grain was recorded with Rd.7, which was 94%. Average percent filled grains of all varieties including: Suphanburi 1, Suphanburi 2, and Suphanburi 60 were 97%, 96%, and 97%, respectively (Table 23).

5.5.6. Harvest index

Results of analysis of variance showed that interactions between nutrient management and varieties led to significant differences in harvest index ($P \leq 0.05$). On average, the highest harvest index of 0.56 was recorded with Suphanburi 90 which received *S. rostrata* treatment. In contrast, the lowest harvest index of 0.42 was observed with Rd. 6 variety which received (16-20-0) + (46-0-0) treatment (Table 26).

Analysis of variance also showed that harvest index of tested varieties were significantly different ($P \leq 0.05$). The highest harvest index was observed with Suphanburi 2, which was 0.52, while the lowest harvest index was recorded with Rd.7, which was 0.44. Average harvest index of Suphanburi 1 was 0.49. For Suphanburi 60, Suphanburi 90 and Chinat both had an equal average harvest index of 0.50 (Table 23).

5.5.7. Plant height

Results of analysis of variance showed that plant heights were strongly affected by nutrients management ($P \leq 0.05$). The highest plant height was observed in *S. rostrata* treatment, which was 116 cm. In contrast, the lowest plant height was recorded in Control treatment, which was 105 cm. Average plant heights of plots receiving (16-20-0) + (46-0-0) and *S. rostrata* + (46-0-0) were 110 cm., and 113 cm., respectively (Table 22).

In addition, results of analysis of variance also showed that plant heights of tested varieties were significantly different ($P \leq 0.05$). Among the varieties tested, the highest plant height was recorded with Suphanburi 1, which was 120 cm., while the lowest was observed in Suphanburi 2 which was 102 cm. Average plant heights of all varieties including: Suphanburi 60, Suphanburi 90, Rd. 7, and Chinat were 114 cm., 114 cm., 110 cm., and 107 cm., respectively (Table 23).

5.5.8. Panicles per square meter

Results of analysis of variance indicated that panicles per square meter of rice grown under different nutrient managements were highly significantly different ($P \leq 0.01$). The highest panicles per square meter was observed in *S. rostrata* + (46-0-0) treatment, which was 266 panicles, while the lowest panicles per square meter was recorded in Control treatment, which was 199 panicles. Average panicles per square meter of plot receiving *S. rostrata* and (16-20-0) + (46-0-0) were 245 panicles and 211 panicles, respectively (Table 22)

5.5.9. Tillers per square meter

Results of analysis of variance showed that tillers per square meter were significantly different (P ≤ 0.05). The highest tillers per square meter was observed in *S. rostrata* + (46-0-0) treatment, which was 301 tillers, while the lowest tillers per square meter was recorded in Control treatment, which was 226 tillers. Average tillers per square meter of plots receiving *S. rostrata* and (16-20-0) + (46-0-0) were 273 tillers and 240 tillers, respectively (Table 22).

5.5.10. Percent productive tillers

Results of analysis of variance showed that percent productive tillers of tested varieties were significantly different (P ≤ 0.05). Among the varieties tested, the highest percent productive tillers were recorded with Suphanburi 1 and Rd. 7, which were 90%, while the lowest was observed with Chinat, which was 86%. The average percent productive tillers of all varieties including: Suphanburi 2, Suphanburi 60, and Suphanburi 90 were 88%, 87%, and 87%, respectively (Table 23).

5.5.11. The 1000 grains weight

Results of analysis of variance showed that 1000 grains weights of tested varieties were significantly different (P ≤ 0.05). Among the varieties tested, the highest of 1000 grains weight was recorded with Suphanburi 1, which was 29.23 grams, while the lowest was observed with Suphanburi 2, which was 24.65 grams. Average1000 grains weights of all varieties including: Suphanburi 60, Suphanburi 90, Rd. 7 and Chinat were 30.45 grams, 28.13 grams, 28.41 grams and 28.97 grams, respectively (Table 23).

Table 22. Plant height and yield characteristics of modern HYV rice as affected by nutrient managements

Nutrient managements	Total straw yield (t ha^{-1})	Total grain yield (t ha^{-1})	Total biomas s yield (t ha^{-1})	Total filled grain yield (t ha^{-1})	Height (cm.)	Panicles /m^2	Tillers / m^2
Control	4.06	3.96	8.02	3.83	105	199	226
S. rostrata	5.33	5.48	10.80	5.31	116	245	273
(16-20-0) + (46-0-0)	5.10	4.79	9.89	4.65	110	211	240
S. rostrata + (46-0-0)	5.73	5.59	11.32	5.36	113	267	301
LSD (0.05)	0.80	0.12	0.85	0.08	4.4	25	37

Table 23. Plant height and yield characteristics of modern HYV rice as affected by varieties

Varieties	% filled grains	Harvest Index	Height (cm.)	% productive tiller	1000 grains weight (g)
Supanburee 1	97	0.49	119	90	29.23
Supanburee 2	96	0.53	102	88	24.65
Supanburee 60	97	0.50	114	87	30.45
Supanburee 90	98	0.50	114	87	28.13
RD. 7	94	0.44	110	90	28.41
Chinat	98	0.50	107	86	28.97
LSD (0.05)	2	0.04	3.3	2	1.07

Table 24. Total straw yield (t ha $^{-1}$) of modern HYV rice as affected by interaction of nutrient
management and varieties

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
Supanburee 1	3.66	5.98	6.28	6.26	5.55	1.26
Supanburee 2	3.46	5.29	3.72	4.85	4.33	0.88
Supanburee 60	3.60	5.19	3.69	6.18	4.67	1.25
Supanburee 90	4.95	4.96	6.20	5.61	5.43	0.60
RD. 7	4.96	4.85	6.01	5.66	5.37	0.56
Chinat	3.75	5.71	4.70	5.81	4.99	0.97
Mean	4.06	5.33	5.10	5.73		
SD	0.70	0.44	1.22	0.51		
% Increased	0	31.17	25.51	40.98		

LSD interaction = 1.87

Table 25. Total biomass yield (t ha^{-1}) of modern HYV rice as affected by interaction of nutrient management and varieties

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
Supanburee 1	7.56	11.78	11.88	12.89	11.03	2.37
Supanburee 2	7.62	10.96	7.91	12.29	9.70	2.30
Supanburee 60	7.18	10.81	8.02	10.24	9.06	1.74
Supanburee 90	9.44	11.26	11.10	11.71	10.88	0.99
RD. 7	8.71	9.20	10.40	11.31	9.91	1.18
Chinat	7.61	10.82	10.02	11.98	10.11	1.85
Mean	8.02	10.81	9.89	11.74		
SD	0.86	0.87	1.62	0.91		
% Increased	0	34.73	23.30	46.34		

LSD interaction = 2.98

Table 26. Harvest index of modern HYV rice as affected by interaction of nutrient management and varieties

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
Supanburee 1	0.52	0.50	0.47	0.49	0.50	0.02
Supanburee 2	0.55	0.52	0.53	0.53	0.53	0.01
Supanburee 60	0.50	0.52	0.54	0.47	0.51	0.03
Supanburee 90	0.48	0.56	0.44	0.50	0.50	0.05
RD. 7	0.43	0.47	0.42	0.45	0.44	0.02
Chinat	0.50	0.47	0.53	0.51	0.50	0.03
Mean	0.50	0.51	0.49	0.49		
SD	0.04	0.03	0.05	0.03		
% Increased	0	2.01	-2.00	-2.00		

LSD interaction = 0.06

5.5.12. Discussion

Rainfall during the study period at the Irrigated Research Station of the Multiple Cropping Center, Chiang Mai University was higher than average. Total rainfall recorded was 1600 m.m which was higher than the preceding year. Solar radiation peak was observed in March to May, with an average of 16 MJ/m^2. The lowest solar radiation occurred in June, which is the start of the rainy season. However accumulated solar radiation in the growing period was less than the preceding year. This phenomenon is thought to have affected the growth of rice, which consequently resulted in lower yields.

Average dry weight of *S. rostrata* planted at the Irrigated Research Station of the Multiple Cropping Center, Chiang Mai University varied from 2.6 to 4.8 t ha^{-1}. Average N content was 3.1%. N equivalent varied from 80.6-148.8 kgN ha^{-1}. This amount is similar to that reported by other workers. Vejpas *et al.* (1990), for instance, reported that, in comparison with leguminous green manure crops, *Sesbania rostrata* is highly productive in that the crop with 30 to 75 days after sowing can give biomass yield ranging from 10 to more than 30 t fresh weight per hectare with 50-270 kgN, and increase successive rice yield from 0.2 to 2 t ha^{-1} (in Nguyen, 1992). Results of field experiments on the effect of *S. rostrata* on rice in the Philippines also demonstrated a significant increase in grain yields of rice. Diekmann *et al.* (1996), for example, reported that the incorporation of the 49 days old *S. rostrata* accumulated up to 190 kg N ha^{-1} which resulted in increases in grain yields by 1.3-1.7 t ha^{-1} in at in Luzon and 6.5 t ha^{-1} in Los Banõs.

Results of this experiment demonstrated that the selected glutinous and non-glutinous rice varieties grown under different nutrient management practices had resulted in a significant response in total straw and biomass yields, and plant heights as compared to Control treatment. The differences in the former two characteristics occurred in the *S. rostrata* + (46-0-0) treatment, while the later occurred in *S. rostrata* treatment. Nevertheless, all the nutrient management practices rendered no differences in other yield characteristics such as total grain yield, total filled grain yield, percent filled grain, harvest index, panicles per square meters, tillers per square meters, percent productive tillers, and 1000 grains weight.

Each of nutrient management practices gave higher total straw yield, total biomass yield, and plant height than Control. Yet, although the greatest total straw yield, total biomass yield and plant height were found in *S. rostrata* + (46-0-0) management practice, they were not significantly different from *S. rostrata* management practice ($P > 0.05$). In comparison with the (16-20-0) + (46-0-0) management practice, the Department of Agriculture's recommended practice, both *S. rostrata* + (46-0-0) and *S. rostrata* management practices gave greatest total straw and biomass yields and plant heights. However, the highest plant height of glutinous and non-glutinous rice varieties was observed in *S. rostrata* treatment, which was 138.9 c.m. This appears to suggest that, although supplementary nutrients are necessary for the growth of rice crops, their responses on certain characteristics to these nutrients may vary depending on their biological characteristics and the types and sources of nutrients. It is probably true given the finding of this study that the selected varieties are highly responsive, in terms of plant height, to nutrients released from *S. rostrata*. This finding is similar to that found in the study conducted by Tudsanee *et al.* (1993) in a 4 year experiment that the height plant high of rice was recorded at *S. rostrata* treatment.

The statistical indifferences in other yield characteristics, such as, total grain yield, total filled grain yield, percent filled grain, harvest index, panicles per square meters, tillers per square meters, percent productive tillers, and 1000 grains weight may be counted as the biological commonalities shared by these tested varieties that have no response to the levels of nutrient management practices used. With special references to the two important yield characteristics like total grain yield, total filled grain yield, the findings of this experiment apparently revealed that all the nutrient management practices are not effective enough to produce a significant agronomic effect on the group of rice varieties in order to result in a satisfactory yield increase. The total seed yield responses of rice under the three plots where management were practiced was almost equal, which was 3.9 t ha^{-1} and approximately 18% greater than that of the Control treatment (Tables 27 & 28).

Table 27. Total grain yield (t ha^{-1}) of the selected of glutinous and non glutinous rice varieties as affected by nutrient management and varieties.

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
RD. 6	3.41	4.20	4.19	4.10	3.98	0.38
Dangkornkaen	2.89	3.48	3.50	3.10	3.24	0.30
RD. 23	3.48	3.94	4.15	4.81	4.10	0.55
Sanpathong	3.52	4.06	4.34	3.19	3.78	0.52
Chinat	3.98	4.50	4.39	4.58	4.36	0.27
Niew-Ubol	3.39	4.39	3.71	4.25	3.94	0.47
Mean	3.45	4.10	4.05	4.01		
SD	0.35	0.36	0.36	0.71		
% yield increasing	0	18.87	17.46	16.26		

Table 28. Total filled grain yield (t ha^{-1}) of the selected of glutinous and non glutinous rice varieties as affected by nutrient management and varieties.

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
RD. 6	3.30	4.10	4.08	3.92	3.85	0.38
Dangkornkaen	2.82	3.28	3.41	2.86	3.09	0.30
RD. 23	3.36	3.79	3.89	4.65	3.92	0.54
Sanpathong	3.34	3.92	4.15	3.60	3.75	0.36
Chinat	3.84	4.31	4.31	4.51	4.24	0.28
Niew-Ubol	3.30	4.31	3.65	4.12	3.85	0.46
Mean	3.33	3.95	3.92	3.94		
SD	0.32	0.39	0.34	0.65		
% yield increasing	0	18.79	17.69	18.54		

Of the glutinous and non-glutinous varieties tested, RD. 23 is the most productive rice variety. Its mean filled grain yield across treatments (3.92 t ha^{-1}) was the greatest mean yield compared to other varieties. Its mean filled grain yield (4.65 t ha^{-1}) recorded in the *S. rostrata* + (46-0-0) treatment was the greatest one compared with those of other varieties under the same nutrient management practice. In comparison with other varieties, other important characteristics of this variety include the shortest plant height (105 cm), the highest productive tillers (89%), and the highest number of panicle (205).

Similarly, the nutrient management practices superimposed in the this experiment had a significant effect on only three yield characteristics, including total straw yield ($P \leq 0.05$) and total biomass yield ($P \leq 0.01$) and plant height ($P \leq 0.01$), of the selected quality rice varieties. Best performances of all these characteristics were observed under the *S. rostrata* + (46-0-0) treatment only. The highest total straw and biomass yields, and plant height were estimated at 8 t ha^{-1} and 12.77 t ha^{-1}, and 135.7 cm., respectively, were recorded under this practice, while the lowest were observed in Control treatment. Other characteristics such as total grain yield, total filled grain yield, percent filled grain, harvest index, panicles per square meters, tillers per square meters, percent productive tillers, and 1000 grains weight were not affected by the nutrient managements; however, poorer performances were often observed in the Control treatment compared to experimental plots with nutrient management practices. It should be noticed as well that when plant height responses of the above groups of rice varieties occurred in the *S. rostrata* treatment, plant height responses of this group of selected quality rice varieties occurred in the *S. rostrata* + (46-0-0) treatment. Additional application of (46-0-0) fertilizer had increased nutrient response of plant heights of this group of rice varieties.

Although statistical differences in total grain yields between the nutrient management practices were not achieved better yield responses of these varieties normally evidenced in experimental plots with *S. rostrata*. The highest total filled grain yield response (4.52 t ha^{-1}) was recorded in the *S. rostrata* + (46-0-0) treatment, which was 26.89%, 4.36%, and 15.89% greater than the Control, *S. rostrata*, and (16-20-0) + (46-0-0), respectively. From these facts it is clearly seen that *S. rostrata*, incorporated into the soil with or without chemical fertilizer (46-0-0), still had greater potentials for increasing yield potentials of these group of rice varieties, though further considerations have to be made as to what levels of *S. rostrata* and chemical fertilizer combination are appropriate for realizing a significant yield improvement (Tables 29 &30).

Table 29. Total grain yield (t ha^{-1}) of selected quality rice varieties as affected by nutrient management and varieties.

Varieties	Control	*S.rostrata*	(16-200) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
Chinat	4.06	4.99	4.01	5.24	4.58	0.63
KDML 105	3.70	3.96	4.26	4.40	4.08	0.31
Pitsanuloke 60-1	3.47	4.88	3.54	3.95	3.96	0.65
RD. 15	3.64	4.25	3.82	4.62	4.08	0.44
Dangmali	3.75	4.12	3.95	4.50	4.08	0.32
Pitsanuloke 60-2	3.90	5.42	4.75	5.76	4.96	0.82
Mean	3.75	4.60	4.06	4.75		
SD	0.21	0.58	0.41	0.65		
% yield increasing	0	22.65	8.04	26.42		

Table 30. Total filled grain yield (t ha^{-1}) of selected quality rice varieties as affected by nutrient management and varieties.

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
Chinat	3.92	4.76	3.82	5.01	4.38	0.60
KDML105	3.46	3.76	4.00	4.06	3.82	0.27
Pitsanuloke 60-1	3.28	4.64	3.76	3.76	3.86	0.57
RD. 15	3.54	4.14	3.72	4.52	3.98	0.44
Dangmali	3.60	3.75	3.90	4.34	3.90	0.32
Pitsanuloke 60-2	3.55	5.11	4.51	5.40	4.64	0.82
Mean	3.56	4.36	3.95	4.52		
SD	0.21	0.56	0.29	0.61		
% yield increasing	0	22.53	11.05	26.89		

Pitsanuloke 60-2 was proved the best variety having highest mean filled grain yield (4.64 t ha^{-1}) across treatments compared with other varieties (Table 30). Its mean filled grain yield (5.76 t ha^{-1}) recorded in the *S. rostrata* + (46-0-0) treatment was the greatest one compared with those of other varieties under the same nutrient management practice. Other distinguished characteristics as compared to other varieties include the lowest plant height (111 cm.), highest productive tillers (90%) and number of panicle (223), and the highest total biomass yield (11.86 t ha^{-1}).

Unlike the other two groups of rice varieties, the HYV rice had better responses to nutrient management practices on various important yield characteristics including total grain yield ($P \leq 0.01$), total biomass yield ($P \leq 0.01$), total filled grain yield ($P \leq 0.01$), total straw yield ($P \leq 0.05$), panicles per square meter ($P \leq 0.01$), plant height ($P \leq 0.05$) and tillers per m^2 ($P \leq 0.05$). All of the highest nutrient responses of these characteristics, but the highest plant height response that was recorded in the *S. rostrata* treatment, appeared in *S. rostrata* + 46-0-0 treatment. Percent filled grain, harvest index, percent productive tillers, and 1000 grains of rice were not affected by nutrient management practices. The better nutrient response of this group of rice varieties could be attributed to an even distribution of the absorbed nutrients within the plant components, and, to particular characteristics of the rice varieties themselves. Better responses of these varieties under the *S. rostrata* + (46-0-0) treatment resulted in the greatest mean grain yield (5.37 t ha^{-1}), which is 40.18%, 1.43%, and 18.77% greater than the Control, *S. rostrata*, and (16-20-0) + (46-0-0), respectively (Table 31). This result is similar to that reported by other workers Arurin et al. (1994), for instance, report that, In Thailand, Arunin *et al.* (1995) revealed that *S. rostrata* gave the highest rice yield in both the saline and non-saline soils. Although the average N-contents of *S. rostrata* in non-saline soils were higher than those in the saline soils, rice yields obtained from the fields under these two soil types receiving *S. rostrata* green manure plus fertilizers were respectively 90% and 29% greater than those obtained from fields with only *S. rostrata*. Bar *et al.* (2000) also found that rice growing in rotation with *S. rostrata* where N was top dressed gave the highest grain yield and highest percentage increase over the control (120%), while incorporating *S. rostrata* alone without N application resulted in a lower yield increase (34%) over control. In a field trial conducted by the Land Development Department, Thailand, it was found that the application of N-P-K at the rate of 50-50-50 kg ha^{-1} along with the incorporation of *S. rostrata* to both non-saline and saline soils increased rice grain yields by 58% and 10% respectively compared to those received from the fields with only *S. rostrata* (Arunin, 1996).

The results of this experiment showed that Supanburee 90 is the most responsive high-yielding variety. Its mean filled grain yield across treatments

(5.23 t ha^{-1}) was the greatest compared to those of other varieties. It preformed very well in the *S. rostrata* + (46-0-0) treatment giving an average yield of 6.15 t ha^{-1} (Table 32).

Table 31. Total seed yield (t ha^{-1}) of modern HYV rice as affected by nutrient management and varieties

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
Supanburi 1	3.90	5.80	5.60	6.02	5.33	0.97
Supanburi 2	4.16	5.68	4.18	5.39	4.85	0.80
Supanburi 60	3.58	5.62	4.33	5.54	4.77	0.99
Supanburi 90	4.49	6.30	4.90	5.70	5.35	0.81
RD. 7	3.75	4.35	4.39	4.71	4.30	0.40
Chinat	3.86	5.11	5.32	6.16	5.11	0.95
Mean	3.96	5.48	4.79	5.59		
SD	0.32	0.67	0.58	0.52		
% yield increasing	0	38.42	20.98	41.20		

Table 32. Total good seed yield (t ha^{-1}) of modern HYV rice as affected by nutrient management and varieties

Varieties	Control	*S.rostrata*	(16-20-0) + (46-0-0)	*S.rostrata* + (46-0-0)	Mean	SD
Supanburi 1	3.81	5.66	5.46	5.78	5.18	0.92
Supanburi 2	3.98	5.54	4.05	5.18	4.69	0.79
Supanburi 60	3.49	5.46	4.20	5.34	4.62	0.94
Supanburi 90	4.44	6.15	4.80	5.51	5.23	0.76
RD. 7	3.55	4.06	4.18	4.30	4.02	0.33
Chinat	3.70	5.00	5.20	6.09	5.00	0.99
Mean	3.83	5.31	4.65	5.37		
SD	0.35	0.72	0.59	0.61		
% yield increasing	0	38.75	21.42	40.18		

It is always perceived that proper nutrient supplementations are keys to better growth and increased yields of rice crops. Overall, as demonstrated by this recent experiment, the use of *S. rostrata* as green manure did have a positive effect on yields and various yield components of rice although they were sometimes not significant as compared with both the Control and chemical fertilizer-based treatment. *S. rostrata* efficacy is even increased when used with chemical fertilizer (46-0-0). In this experiment, it was demonstrated that incorporation of *S. rostrata* at the rate of 3.8 t ha^{-1}, equivalent to 116 kgN, together with additional application of urea (46-0-0) at the rate of 62.5 kg ha^{-1} was proved to have resulted in better responses from all groups of rice varieties tested than did other treatments. This is referred to the differences in the many yield characteristics such as total biomass yield, total straw yields, numbers of panicles and tillers per m^2, percent productive tillers, percent good seed, and 1000 grains weight and so on; although the levels of responses were statistically insignificant. Nevertheless, with respect to grain yield, which is the most significant indicator for assessing crop responses to particular nutrient management practices, only the high-yielding varieties that demonstrated such a significant yield increase under this nutrient management practice. Nutrient responses of the glutinous and non-glutinous and quality rice varieties on other yield components, particularly biomass and straw yields and plant heights, other than yields may have caused from the oversupply of nitrogen, with which plants may have enjoyed a luxury growth rather than producing grain yields. It is therefore worth pointing out that if farmers in the rainfed lowland area of Chiang Mai are to benefit from the green manuring of *S. rostrata* they have to apply urea fertilizer and use the high-yielding varieties. In case that the selected glutinous and glutinous rice varieties are used, farmers are likely to sacrifice their immediate benefits because, as shown in this experiment, the obtained yields were not satisfactory. But, they may regain the benefits in the following years when nutrient residues released from *S. rostrata* have accumulated to sufficiently meet the N needs of rice crops.