

EFFECT OF SITE SPECIFIC NUTRIENT MANAGEMENT AND IMPROVING SEED RATE IN ALLUVIUM AND MEDIUM ACID SULFATE SOILS ON GRAIN YIELD, NUTRIENT USE EFFICIENCY AND PROFIT OF RICE PRODUCTION IN THE MEKONG DELTA

Trinh Quang Khuong¹, Tran thi Ngoc Huan¹, Phạm Sy Tan¹ and Ngo Ngoc Hung²

¹ Cuu Long Delta Rice Research Institute, Can Tho, Viet Nam (CLRRI)

² Cantho University, Cantho City, Vietnam

ABSTRACT

The research with field experiments design and omission plot technique in order to evaluate and compare efficacy of Site Specific Nutrient Management (SSNM-P₁N₁) and (SSNM-P₂N₁) with Farmer's Fertilizer Practice (FFP-P₂N₂) on rice yield and nutrient use efficiency. The experiments were conducted in two provinces of Cantho and Kiengiang in 2007-08 with three seasons/year Summer-Autumn (LWS); Winter-Spring (DS); Spring-Summer (EWS). The results showed the remarkable differences in grain yield and nutrient use efficiency among two fertilizer application methods and two seed rates. Grain yield of SSNM-P₁N₁ was higher than that of SSNM-P₂N₁ and FFP-P₂N₂ about 0.33-0.51 ton ha⁻¹. SSNM-P₁N₁ supported to increase nutrient use efficiency of N, P and K. AEN and REN of SSNM-P₁N₁ method were higher than those of SSNM-P₂N₁ and FFP-P₂N₂. AEN of SSNM-P₁N₁ method got from 14.6 to 19.3 kg grain/kg N, higher than that of FFP-P₂N₂ method from 1.7 to 4.4 kg grain/kg N. Especially, REN attained at high value. It got from 0.41 to 0.49. SSNM-P₁N₁ supported to remarkable decrease of N fertilizer and seed rates. It reduced at average of 10-20 kg N/ha and 80 kg seeds/ha. On economic efficiency, SSNM-P₁N₁ helped to reduce fertilizer and seed costs from 0.44 to 2.4 million VND ha⁻¹. SSNM-P₁N₁ that contributed to increase income and profit for rice growing farmers. It increased from 0.6-3.9 million VND/ha. Indeed, SSNM-P₁N₁ is a new and efficient management practices. It should be trained and widely spread to farmers in combination with the programs such as IPM, high quality rice seed production, "three reductions, three gains", and so on.

Keywords: Agronomy Efficiency of Nitrogen (AEN), Farmer Fertilizer Practice (FFP), Integrated Pest Management (IPM), Nutrient Use Efficiency (NUE), Recovery Efficiency of Nitrogen (REN), Site Specific Nutrient management (SSNM).

INTRODUCTION

Rice production in the Mekong Delta (MRD) is an important factor for food security in Vietnam and rice export. However, little is known about the sustainability of the current production systems, particularly systems with triple rice cropping system and minimum tillage. Intensive rice monoculture may lead to increased weed, disease, and insect pressure. Poor seed quality, low N-use efficiency, deteriorating soil fertility and stagnating rice productivity are other major concerns (Tan et al. 2004). Mineral fertilizer inputs have become dominant factors of the overall nutrient balance, but their use is often

unbalanced and their efficiency remains low optimum levels. Managing the variability in soil nutrient supply that has resulted from intensive rice cropping is one of the challenges to sustaining and increasing rice yields in the Mekong Delta (Dobermann et al. 1996; Witt et al. 1999).

Site Specific Nutrient Management (SSNM) provides an approach for "feeding" rice with nutrients as needed. Researchers developed the SSNM approach in the mid-1990s and evaluated it from 1997 to 2000 on about 200 irrigated rice farms at eight sites in Asia. Since 2001, the on-farm evaluation and promotion of SSNM have markedly increased. In 2003-04, SSNM was

evaluated and promoted with farmers at about 20 locations in tropical and subtropical Asia. Each was representing an area of intensive rice farming on more than 100,000 ha with similar soils and cropping systems. The SSNM approach does not provide one universal nutrient management practice for rice. It instead enables the tailoring of nutrient management to field- and location-specific conditions. Recommendations for managing nutrient inputs are consequently adapted to local conditions and vary among fields and locations (Buresh et al. 2005). Vietnam is one of the countries involved in this research program. Research on “Effect of Site Specific Nutrient Management on grain yield and nutrient use efficiency of Cantho, An Giang and Tiengiang Province in 2004” is a part of study on SSNM in the Mekong Delta in order to evaluate and

compare efficacy of SSNM on rice yield and nutrient use efficiency and profit of rice production in the Mekong Delta (Khuong et al. 2007). This paper shows the results of the research on the combination of seeding rate, nitrogen application method at two sites (alluvium and medium acid sulfate soils on rice grain yield. It will evaluate the impact of these management practices on grain yield and net benefit of intensive rice production.

MATERIALS AND METHODS

Characters of surface of soil (0-20 cm), N total recorded from 0.15 to 0.18 %N, available P was from 0.41 to 1.17 mg/kg soil and pH from 5.0 to 3.8 in Cantho and Kiengiang, respectively.

Table 1. Characters of surface of soil (0-20 cm) in Cantho and Kiengiang.

Sites	pH	EC mS/cm	N total (%N)	Carbon (%C)	Texture of soil (%)			P available Bray No.2
					Sandy	Heavy	Clay	
Cantho	5.0	0.38	0.15	1.34	6.0	48.6	45.4	0.41
Kiengiang	3.8	2.30	0.18	2.08	4.0	41.5	54.5	1.17

The experiments were done on triple rice cropping system: late 2007 wet season (S-A), 2007-08 dry season (W-S) and early 2008 wet season (S-S) at two sites (CLRRI, Cantho and Giongrieng, Kiengiang). The treatments were the combination

of seeding rate (120 and 200 kg seed ha⁻¹) and nitrogen management methods (Table 2). They were laid out in a randomized complete block design with four replications and seven treatments.

Table 2. The treatments of the experiments in Cantho and Kiengiang

No.	Treatment	Description	N application methods	Seeding rates
1	PK	PK based on recommendation	- N	Broadcasting 200 kg seed/ha
2	NK	K based on recommendation	N based on recommendation	Broadcasting 200 kg seed/ha
3	NP	P based on recommendation	N based on recommendation	Broadcasting 200 kg seed/ha
4	NPK	PK based on recommendation	N based on recommendation	Broadcasting 200 kg seed/ha
5	P ₁ N ₁	PK based on recommendation	N based on LCC	Row seeding 120 kg seed/ha
6	P ₂ N ₁	PK based on recommendation	N based on LCC	
7	P ₂ N ₂	NPK based on farmer practice	Farmer fertilizer	

The rate and timing of fertilizer application were followed as Table 3. Nitrogen rate and timing application for rice based on Leaf Color Charge (LCC) and rice growing stages were followed as Table 4.

Table 3. The fertilizer rate and timing of application by SSNM.

Season	Timing of fertilizer application	N (kg N ha ⁻¹)	P (kg P ₂ O ₅ ha ⁻¹)	K (kg K ₂ O ha ⁻¹)
Dry season	7-10 DAS*	30-40	30-40	30
	18-22 DAS*	30-40	0	0
	PI (30-35) DAS*	30-40	0	10
EWS and LWS	7-10 DAS*	20-35	40-50	30
	18-22 DAS*	20-35	0	0
	PI (30-35) DAS*	20-35	0	20

Note: *DAS: Day after sowing

Table 4. The N fertilizer rate (kg/ha) and timing for each split application based on LCC.

LCC	DS		EWS and LWS	
	18-22 DAS	PI (30-35 DAS)	18-22 DAS	PI (30-35 DAS)
> 4	15-20	0	0	0
> 3 to 4	30	30	20	20
<3	40	40	35	35

RESULTS AND DISCUSSION

1. The difference of nitrogen rate and grain yield at two sites: In all 3 seasons, FFP- P₂N₂ treatments were applied nitrogen higher than those

of SSNM-P₁N₁ and SSNM-P₂N₁. SSNM-P₁N₁ treatment was saved of N from 10 to 20 kg N ha⁻¹ compared with SSNM-P₂N₁ and FFP- P₂N₂ at two sites (Table 5).

Table 5. Total amount of fertilizer N applied to rice per season with the farmers' fertilizer practice (FFP- P₂N₂), Site-Specific Nutrient Management (SSNM-P₁N₁; SSNM-P₁N₂) in the Mekong River Delta, Vietnam in 2007-08. *Values shown are the means and standard deviation of two sites.*

N fertilizer rate (kg/ha)	Nitrogen application methods			Difference		
	SSNM-P ₁ N ₁ (1)	SSNM-P ₂ N ₁ (2)	FFP-P ₂ N ₂ (3)	(1)-(3)	(1)-(2)	(2)-(3)
2007LWS	90	100	110	-20	-10	-10
2007-08 DS	100	100	110	-10	0	-10
2008 EWS	90	100	110	-20	10	-10

Grain yield on -N plot was lower than that of -K and -P plots. NK plot grain yield got lower compare with NPK plot in all three seasons and two sites. Omission plots -N; -P; -K and NPK plot showed the difference of N on grain yield varied from 0.90 to 2.68 ton ha⁻¹. The difference on grain yield varied from 0.49 to 1.69 ton ha⁻¹ for P and 0.24 to 0.36 ton ha⁻¹ for K in three seasons and two

sites. Effect of N, P, K on grain yield in Kiengiang were higher than those of Cantho (Figure 1 and Table 6). Beside stabilizing and increasing grain yield of high-yielding rice variety, SSNM helped to save fertilizers. It supported to remarkable decrease of fertilizer rate. It reduced at average of 10-20 kg N ha⁻¹ by season.

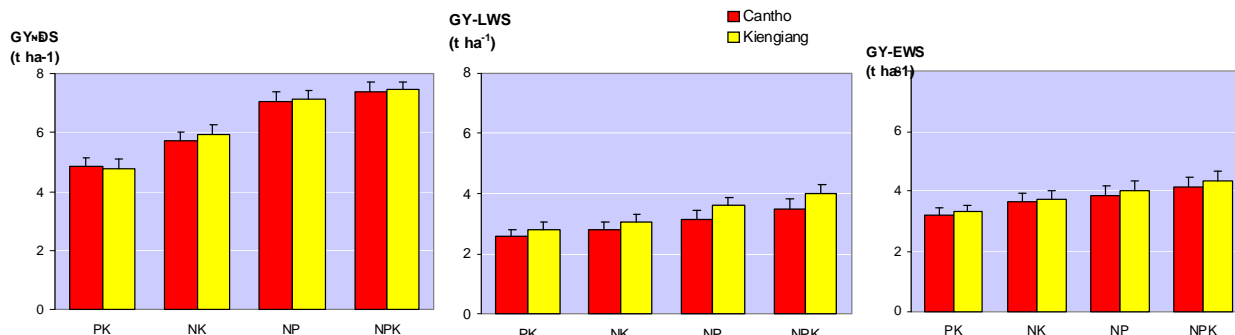


Figure 1. Effect of fertilizer application method on grain yield (t/ha) in Cantho and Kiengiang (2007 LWS, 2007-08 DS and 2008 EWS)

Table 6. Effect of fertilizer application (N, P, K) on grain yield (ton ha⁻¹) in Cantho and Kiengiang.

Treatment	NPK (1)	NP (2)	NK (3)	PK (4)	Difference ^a		
					K=(1)-(2)	P=(1)-(3)	N=(1)-(4)
Cantho							
2007LWS	3.49	3.17	2.78	2.57	0.32 ns	0.71**	0.92**
2007-08DS	7.41	7.05	5.72	4.84	0.36 ns	1.69**	2.57**
2008EWS	4.12	3.88	3.63	3.22	0.24 ns	0.49*	0.90**
Mean	5.01	4.70	4.04	3.54	0.31	0.96	1.46
Kiengiang							
2007LWS	3.97	3.62	3.05	2.81	0.35 ns	0.92**	1.16**
2007-08DS	7.46	7.13	5.94	4.78	0.33 ns	1.52**	2.68**
2008EWS	4.36	4.04	3.74	3.31	0.32 ns	0.62**	1.05**
Mean	5.26	4.93	4.24	3.63	0.33	1.02	1.63

^ans: non significant < 0.05, * significant at 0.05; ** significant at 0.01.

2. Effect of SSNM on nutrient use efficiency (NUE): SSNM supported to increase nutrient use efficiency of N, P and K. AEN, REN, AEP, REP, AEK, REK of SSNM method were higher than those of EFP (Extension Fertilizer Practice) and FFP (Khuong et al. 2007). AEN of SSNM- P₁N₁ method got from 14.6-19.3 kg rice grain/kg N while FFP- P₂N₂ method got AEN from 12.9 to 14.9 kg rice grain/kg applied-N. These values were higher than those of FFP-P₂N₂ method of 1.7-4.4 kg rice grain/kg N in all three seasons and two sites (Table 7). With the same nitrogen fertilizer rate, but grain yield and AEN at Kiengiang site

attained higher than those of Cantho site that was resulted by fertile soil property of Kiengiang.

The REN of SSNM-P₁N₁ and SSNM-P₂N₁ methods attained higher than those of FFP-P₂N₂ value. They got from 0.40 to 0.49, while FFP-P₂N₂ method only got from 0.34 to 0.42 in all three seasons and two sites (Table 8). The difference on REN between two fertilizer application methods was very significant. As a consequence, SSNM improved nitrogen uptake and nitrogen recovery efficiency.

Table 7. Comparison of agronomy efficiency of nitrogen (AEN) among three application methods and seasons (Cantho and Kiengiang).

Sites	Nitrogen application methods			Difference ^a		
	SSNM-P ₁ N ₁ (1)	SSNM-P ₂ N ₁ (2)	SSNM-P ₂ N ₂ (3)	(1-3)	(1-2)	(2-3)
LWS 2007						
Cantho	14.6	13.7	12.9	1.7*	0.9 ns	0.8 ns
Kiengiang	15.9	14.2	13.2	2.7*	1.7*	1.0 ns
DS 2007-08						
Cantho	18.1	16.6	14.9	3.2**	1.5 ns	1.7*
Kiengiang	19.3	17.8	15.6	3.7**	1.5 ns	2.2*
EWS 2008						
Cantho	15.3	14.2	13.3	2.0*	1.1 ns	0.9 ns
Kiengiang	16.4	15.5	14.6	1.8*	0.9 ns	0.9 ns

^ans: non significant < 0.05, * significant at 0.05; ** significant at 0.01.

Table 8. Comparison of recovery efficiency of nitrogen (REN) among three application methods and seasons (Cantho and Kiengiang).

Sites	Nitrogen application methods			Difference ^a		
	SSNM-P ₁ N ₁ (1)	SSNM-P ₂ N ₁ (2)	FFP-P ₂ N ₂ (3)	(1-3)	(1-2)	(2-3)
LWS 2007						
Cantho	0.41	0.40	0.35	0.06*	0.01ns	0.05*
Kiengiang	0.43	0.42	0.34	0.09**	0.01 ns	0.08*
DS 2007-08						
Cantho	0.46	0.42	0.39	0.07*	0.04*	0.03 ns
Kiengiang	0.49	0.43	0.42	0.07*	0.06*	0.01 ns
EWS 2008						
Cantho	0.45	0.42	0.37	0.08*	0.03*	0.05*
Kiengiang	0.44	0.44	0.40	0.04*	0.00 ns	0.04*

^ans: non significant < 0.05, * significant at 0.05; ** significant at 0.01.

3. Effect of SSNM on profit of rice production in the Mekong Delta:

The input for rice production between two sites varied from VND 10.255 to 12.901 million ha⁻¹. The fertilizer and seed costs input of SSNM was lower than FFP method. The difference in fertilizer and seed rate costs among treatments were from 0.4 to 2.4 million VND ha⁻¹ in Cantho and from VND 0.4 to 1.508 million ha⁻¹ in Kiengiang. The profit among

treatments was also very different. The profit of SSNM-P₁N₁, SSNM-P₂N₁ methods were higher than those of FFP-P₂N₂ method. It got from VND 0.626 to 3.565 million ha⁻¹ in LWS, from VND 1.548 to 3.860 million ha⁻¹ in DS and from VND 1.326 to 3.188 million ha⁻¹ in EWS. The profit of SSNM and row-seeding (SSNM-P₁N₁) method was the highest in all three seasons and both 2 sites (Table 9 and 10).

Table 9. Effect of nitrogen application methods and seed rates on profit of rice production in Cantho

Season	Treatment	Grain yield (t/ha)	Output (1,000VND)	Input ^a (1,000VND)	Profit (1,000VND)	Diff. (1,000VND)
2007 LWS	SSNM-P ₁ N ₁	3.60	17,280	12,024	5,257	2,461
	SSNM-P ₂ N ₁	3.31	15,888	12,464	3,425	629
	FFP-P ₂ N ₂	3.27	15,696	12,901	2,796	-
2007-08DS	SSNM-P ₁ N ₁	7.51	30,040	10,921	19,119	3,860
	SSNM-P ₂ N ₁	7.28	29,120	11,361	17,759	2,500
	FFP-P ₂ N ₂	7.00	28,000	12,741	15,259	-
2008EWS	SSNM-P ₁ N ₁	4.31	18,102	10,255	7,847	3,188
	SSNM-P ₂ N ₁	4.15	17,430	10,655	6,775	2,116
	FFP-P ₂ N ₂	3.91	16,422	11,763	4,659	-
Mean		4.93	20,886	11,676	9,211	

^a Price of rice: LWS=4,800 VND/kg; DS= 4,000 VND/kg and EWS=4,200 VND/kg

Table 10. Effect of nitrogen application methods and seed rates on profit of rice production in Kiengiang.

Season	Treatment	Grain yield (t/ha)	Output (1,000VND)	Input ^a (1,000VND)	Profit (1,000VND)	Diff. (1,000VND)
2007 LWS	SSNM-P ₁ N ₁	4.60	22,080	12,024	10,057	3,565
	SSNM-P ₂ N ₁	4.28	20,544	12,464	8,081	1,589
	FFP-P ₂ N ₂	4.04	19,392	12,901	6,492	-
2007-08DS	SSNM-P ₁ N ₁	8.27	33,080	10,255	22,825	3,268
	SSNM-P ₂ N ₁	7.94	31,760	10,655	21,105	1,548
	FFP-P ₂ N ₂	7.83	31,320	11,763	19,557	-
2008EWS	SSNM-P ₁ N ₁	4.65	19,530	11,047	8,484	2,846
	SSNM-P ₂ N ₁	4.45	18,690	11,727	6,964	1,326
	FFP-P ₂ N ₂	4.26	17,892	12,255	5,638	-
Mean		5.59	23,810	11,676	12,133	

^a Price of rice: LWS=4,800 VND/kg; DS= 4,000 VND/kg and EWS=4,200 VND/kg

CONCLUSION

SSNM in combination with row-seeding is a new and effective management practices. It helped to save 10-20 kg N ha⁻¹ and reduce 80 kg seed ha⁻¹, stabilizing and increasing of 0.33-0.51 ton ha⁻¹ rice grain yield. AEN increased from 1.7 to 4.4 kg rice/kgN and REN increased from 0.06 to 0.08. SSNM-P₁N₁ contributed to increase profit of VND 0.6 to 3.9 million ha⁻¹ for rice growing farmers. So, it should be trained and widely spread to farmers in combination with the programs such as IPM, high quality rice seed production, "three

reductions, three gains" and etc...

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Ảnh hưởng của Quản lý dinh dưỡng theo địa điểm chuyên biệt và cải tiến mật độ sạ ở đất phù sa và đất phèn trung bình trên năng suất lúa, hiệu quả sử dụng phân bón và lợi nhuận của sản xuất lúa ở Đồng bằng sông Cửu Long

Sử dụng phương pháp bón phân theo địa điểm chuyên biệt (SSNM) được thực hiện trên ruộng nông dân ở Giồng Riềng-Kiên Giang và ruộng thí nghiệm ở Viện Lúa ĐBSCL-Cần Thơ. Sự kết hợp giữa SSNM, phương pháp bón N và cải tiến mật độ sạ được so sánh và đánh giá qua ba mùa vụ: Hè Thu, Đông Xuân và Xuân Hè năm 2007-08. Các nghiệm thức bao gồm: (i) Sạ theo hàng, mật độ 120 kg giống/ha (P_1) và bón phân đạm theo bảng so màu lá (N_1) (SSNM- P_1N_1); (ii) Sạ lan theo kinh nghiệm của nông dân, mật độ 200 kg giống/ha (P_2) và bón phân đạm theo kinh nghiệm của nông dân (N_2) (FFP- P_2N_2); và (iii) Mật độ sạ 200 kg giống/ha (P_2) và bón phân theo bảng so màu lá (N_1) (SSNM- P_2N_1). Kết quả cho thấy SSNM làm gia tăng năng suất và hiệu quả sử dụng phân bón ở cả hai địa điểm nghiên cứu. Năng suất lúa ở phương pháp (SSNM- P_1N_1) đạt cao hơn phương pháp (FFP- P_2N_2) trung bình từ 0,33-0,51 tấn/ha. Hiệu quả nông học (AEN) đạt được đối với SSNM- P_1N_1 là 14,6-19,3 kg lúa/kg N cao hơn so với FFP- P_2N_2 trung bình từ 1,7-4,4 kg lúa/kg N. Hiệu quả thu hồi dinh dưỡng đạm (REN) của SSNM- P_1N_1 đạt từ 0,41-0,49. SSNM- P_1N_1 đã giúp tiết kiệm được 10-20 kg N/ha so với kỹ thuật bón phân của nông dân (FFP- P_2N_2). Sạ hàng giảm được 80 kg giống/ha so với biện pháp sạ vãi của nông dân. Phương pháp bón phân theo SSNM và sạ hàng (SSNM - P_1N_1) đã góp phần tăng lợi nhuận cho người trồng lúa thông qua giảm chi phí phân bón và chi phí giống từ 0,4-2,4 triệu VND/ha và lợi nhuận gia tăng từ 0,6-3,9 triệu đồng/ha. Phương pháp bón phân theo SSNM và sạ hàng là một biện pháp canh tác mới đạt hiệu quả cao. Vì vậy, nên tăng cường tập huấn và mở rộng áp dụng cho nông dân kết hợp với các chương trình như IPM, mô hình nhân giống lúa chất lượng cao, “Ba giảm ba tăng”, v.v...