

EFFECT OF SITE SPECIFIC NUTRIENT MANAGEMENT ON GRAIN YIELD, NUTRIENT USE EFFICIENCY AND RICE PRODUCTION PROFIT IN THE MEKONG DELTA

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ABSTRACT

Evaluation of Site Specific Nutrient Management (SSNM) with Farmer's Fertilizer Practice (FFP) and Extension's Fertilizer Practice (EFP) on rice yield and nutrient use efficiency were conducted on 30 farms at six villages of three provinces as Can Tho, An Giang and Tien Giang in 2004. It showed the remarkable difference in grain yield and nutrient use efficiency among three fertilizer application methods. Grain yield of SSNM was similar or higher than those of EFP and FFP about 0.17 t/ha. SSNM supported to increase nutrient use efficiency of N, P and K. AEN, REN, AEP, REP, AEK, REK of SSNM plot were higher than those of EFP and FFP. AEN of SSNM plot got from 12 to 17 kg grain/kg N, higher than that of FFP plot from 1.1 to 3.4 kg grain/kg N. AEP of SSNM got from 25 to 46 kg grain/kg P₂O₅, higher than that of FFP plot from 2.6 to 7.7 kg grain /kg P₂O₅. AEK attained from 2.4 to 13.4 kg grain/kg K₂O, higher than that of FFP plot from 2.4 to 5.1 kg grain /kg K₂O. Especially, REN attained at high value. It got from 0.51 to 0.56. SSNM supported to remarkable decrease fertilizer doses. It reduced at average of 11 kg N/ha, 5.2 kg P₂O₅/ha and 16 kg K₂O /ha. On economic efficiency, SSNM helped to reduce fertilizer cost from 3.6 to 16.6%. SSNM contributed to increase income and profit for rice growing farmers through the decrease of fertilizer cost and increase of profit and fertilizer cost ratio. Indeed, SSNM is a new and efficient fertilizer application method. 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: AEK, AEN, AEP, EFP, FFP, NUE, Profit/fertilizer cost ratio, REN, SSNM

INTRODUCTION

Rice production in the Mekong Delta (MD) 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 cropping under minimum practice. 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). During the past 25 years, the fluxes of nutrients within a typical irrigated rice field have increased 5 to 7-fold and cannot be met by natural sources such as sediments provided by the Mekong River alone. Mineral fertilizer inputs have become dominant factors of the overall nutrient balance, but their use is often unbalanced and their efficiency remains below 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 is 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. The study on “Effect of Site Specific Nutrient Management on grain yield and nutrient use efficiency of Can Tho, An Giang and Tien Giang provinces 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 and Tan 2005).

MATERIALS AND METHODS

The field experiments were designed on the randomized complete block with three fertilizer application methods of Site Specific Nutrient Management (SSNM), Farmer's Fertilizer Practice (FFP), Extension's Fertilizer Practice (EFP) and applied omission plot technique (-N, -P, -K and -F) on 30 farms at six villages of three provinces of Can Tho, An Giang and Tien Giang in two seasons: 2004 dry season and 2004 wet season.

The high yielding rice varieties such as OM1490, IR50404, OM2718, OM3536 and aromatic rice VD20 and Jasmine 85 were grown. Other management practices as seeding density, pest control, water management, *etc...* were followed by local recommendation.

The data on N, P, K fertilizer amount and timing of application of each fertilizer application method were recorded.

The nutrient content in soil and plant samples were selected and analysed with IRRI's standard method.

The rice yield components and grain yield were selected and analysed with IRRI's procedure.

RESULTS AND DISCUSSION

Effect of SSNM on grain yield

The difference in fertilizer amount of SSNM over 10 sites in each province mainly differed on nitrogen fertilizer amount at both seasons while the amount of all N, P, K fertilizers of FFP plots varied from field to field (Table 1). It also showed that farmers applied at higher N, P, K fertilizer dose than those of SSNM and EFP methods.

The grain yield was affected by fertilizer application method. Grain yield of SSNM plot was similar in 2004 dry season and higher than those of EFP and FFP plots in 2004 wet season about 0.17 ton/ha (Table 2). SSNM supported to remarkable decrease fertilizer doses. It reduced at average of 8.9-10.7 kg N/ha, 1.4-5.2 kg P₂O₅/ha and 3.8-16.3 kg K₂O /ha by season. SSNM helped to save fertilizers, stabilizing and increasing grain yield of high-yielding rice and aromatic rice varieties.

Table 1. Total amount of fertilizer N, P₂O₅, and K₂O applied to rice per season with the farmers' fertilizer practice (FFP), Extension's Fertilizer Practices (EFP) and Site-Specific Nutrient Management (SSNM) in the Mekong River Delta, Vietnam in 2003-04. *Values shown are the means and standard deviation of 10 sites per province.*

Province	SSNM			EFP			FFP		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
2004 Dry Season									
Can Tho	98.1 ±5.7	41.4 ±0.0	36.0 ±0.0	102.6 ±0.0	43.0 ±0.0	45.0 ±0.0	107.6 ±5.6	47.5 ±10.8	43.5 ±7.2
An Giang	100.8 ±0.0	46.0 ±0.0	36.0 ±0.0	101.6 ±0.0	48.4 ±0.0	52.5 ±0.0	110.9 ±10.2	52.0 ±12.7	61.7 ±14.1
Tien Giang	100.5 ±6.8	42.8 ±2.2	36.0 ±0.0	104.9 ±2.4	43.0 ±0.0	39.0 ±0.0	107.7 ±7.4	49.4 ±7.4	49.8 ±9.6
2004 Wet season									
Can Tho	88.8 ±3.2	46.0 ±0.0	36.0 ±0.0	93.4 ±0.0	43.0 ±0.0	45.0 ±0.0	103.4 ±3.8	42.1 ±8.6	35.3 ±6.4
An Giang	97.1 ±2.9	46.0 ±0.0	36.0 ±0.0	96.2 ±0.0	43.0 ±0.0	45.0 ±0.0	111.7 ±12.1	51.7 ±11.3	43.4 ±8.3
Tien Giang	90.2 ±2.2	46.0 ±0.0	42.0 ±0.0	93.7 ±0.9	49.3 ±2.4	45.0 ±3.2	93.3 ±3.3	45.8 ±4.9	46.6 ±4.8

Table 2. The difference in fertilizer amount and grain yield of fertilizer application methods. *Values shown are the means of 30 sites of 3 provinces.*

Items	Fertilizer application methods			Difference ^a		
	SSNM(1)	EFP (2)	FFP (3)	(1-3)	(1-2)	(2-3)
Dry Season 2003-04						
N applied (kg N/ha)	99.8	103.0	108.7	-8.9**	-3.3*	-5.7**
P applied (kg P ₂ O ₅ /ha)	43.4	44.8	48.6	-5.2**	-1.4*	-3.8*
K applied (kg K ₂ O/ha)	36.0	45.5	52.3	-16.3**	-9.5**	-6.8*
Grain yield (t/ha)	6.09	6.05	6.06	0.029 ns	0.043 ns	-0.014 ns
Wet season 2004						
N applied (kg N/ha)	92.1	94.4	102.8	-10.70**	-2.30*	-8.40**
P applied (kg P ₂ O ₅ /ha)	46.0	44.4	46.5	-0.50 ns	1.60*	-2.10*
K applied (kg K ₂ O/ha)	38.0	43.9	41.8	-3.80*	-5.90**	2.10*
Grain yield (t/ha)	5.15	4.98	4.99	0.169**	0.170**	-0.001 ns

^a ns: non significant, * Significant at the level of 0.05; ** Significant at the level of 0.01.

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 plot were higher than those of EFP and FFP. AEN of SSNM plot got from 11.9-17 kg grain/kg N while FFP method got AEN from 10 to 15 kg grain/kg applied-N. This value was higher than that of FFP plot from 1.1-3.4 kg grain/kg N (Table 3). Simultaneously with nitrogen fertilizer dose, grain yield and AEN of sites at An Giang province also attained higher than those of Can Tho and Tien Giang provinces resulted by soil fertiled property of An Giang. REN of SSNM method attained at higher value. It got from 0.51-0.56 while EFP and FFP methods only got REN from 0.42 to 0.53 (Table 4). The difference in REN among three fertilizer application methods was very significant. Consequently, SSNM improved nitrogen plant uptake and nitrogen recovery efficiency.

Table 3. Comparison of Agronomy Efficiency of Nitrogen (AEN) among three fertilizer application methods to rice season and provinces.

Province	Fertilizer application methods			Difference ^a		
	SSNM(1)	EFP (2)	FFP (3)	(1-3)	(1-2)	(2-3)
<i>2004 Dry season</i>						
Can Tho	16.96	14.99	15.26	1.70*	1.97*	-0.27 ns
An Giang	16.50	16.49	15.12	1.38*	0.01 ns	1.37*
Tien Giang	11.90	11.40	10.76	1.09*	0.50 ns	0.59 ns
<i>2004 Wet season</i>						
Can Tho	13.50	11.48	10.10	3.40**	2.02*	1.38*
An Giang	16.54	15.41	13.53	3.01**	1.15 ns	1.86*
Tien Giang	15.65	12.92	13.27	2.38*	2.73**	-0.35 ns

^a ns: non significant, * Significant at the level of 0.05; ** Significant at the level of 0.01.

Table 4. Comparison of Recovery Efficiency of Nitrogen (REN) among three fertilizer application methods to rice season and provinces.

Province	Fertilizer application methods			Difference ^a		
	SSNM(1)	EFP (2)	FFP (3)	(1-3)	(1-2)	(2-3)
<i>2004 Dry season</i>						
Can Tho	0.51	0.47	0.45	0.06**	0.04*	0.02*
An Giang	0.54	0.48	0.44	0.10**	0.06**	0.04*
Tien Giang	0.55	0.47	0.46	0.10**	0.08**	0.01 ns
<i>2004 Wet season</i>						
Can Tho	0.52	0.45	0.42	0.10**	0.07*	0.03 ns
An Giang	0.56	0.53	0.48	0.08**	0.03 ns	0.05*
Tien Giang	0.55	0.49	0.48	0.07*	0.06*	0.01 ns

^a ns: non significant, * Significant at the level of 0.05; ** Significant at the level of 0.01.

For phosphorus and potassium use efficiency, AEP of SSNM got from 25-46 kg grain/kg P₂O₅, higher than that of FFP plot from 2.6-7.7 kg grain /kg P₂O₅. REP of SSNM obtained from 0.25 to 0.33 while it got 0.20-0.28 in FFP. AEK of SSNM method attained from 2.4-13.4 kg grain/kg K₂O, higher than that of FFP plot from 2.4-5.1 kg grain /kg K₂O. REK of SSNM got from 0.46 to 0.50 while it varied from 0.38 to 0.50 in FFP plot. (Khuong and Tan 2005).

Effect of SSNM on profit of rice production

The fertilizer cost among sites and provinces varied from 1.2 to 1.6 million dong/ha in which fertilizer input of SSNM was lower than EFP and FFP methods for both seasons. The difference in fertilizer cost among fertilizer application methods was from 3.6 to 16.6%. This difference between SSNM and FFP was very clear. It varied from 14.2 to 16.6 % in 2004 DS and from 7.0 to 14.3% in 2004 WS (Table 5). Because of low fertilizer cost, the ratio of profit and fertilizer cost of SSNM was higher as compared to EFP and FFP methods (Table 6). SSNM contributed to increase income and profit for rice growing farmers.

Table 5. The difference in fertilizer cost (1,000 dong/ha) of fertilizer application methods of provinces.

Province	Fertilizer application method			Difference ^a		
	SSNM(1)	EFP (2)	FFP (3)	(1-3)	(1-2)	(2-3)
<i>2004 Dry season</i>						
Can Tho	1,193	1,319	1,404	15.1	9.6	6.1
An Giang	1,242	1,406	1,490	16.6	11.7	5.6
Tien Giang	1,217	1,306	1,418	14.2	6.8	7.9
<i>2004 Wet Season</i>						
Can Tho	1,230	1,369	1,421	13.4	10.2	3.7
An Giang	1,341	1,391	1,565	14.3	3.6	11.1
Tien Giang	1,319	1,431	1,419	7.0	7.8	-0.8

^a Different percentage of fertilizer cost

Table 6. The difference in profit/fertilizer cost ratio of fertilizer application methods of provinces.

Province	Profit/fertilizer cost ratio			Difference		
	SSNM(1)	EFP (2)	FFP (3)	(1-3)	(1-2)	(2-3)
<i>2004 Dry season</i>						
Can Tho	6.90	5.94	5.58	1.31	0.96	0.35
An Giang	7.08	5.97	5.60	1.48	1.11	0.37
Tien Giang	5.94	5.47	4.73	1.21	0.47	0.74
<i>2004 Wet Season</i>						
Can Tho	3.18	2.67	2.29	0.89	0.51	0.38
An Giang	5.59	5.03	4.12	1.47	0.56	0.91
Tien Giang	6.30	5.51	5.84	0.46	0.79	-0.32

CONCLUSION

SSNM is a new and effective fertilizer application method. It can save fertilizers, stabilize and raise grain yield and nutrient use efficiency and reduce fertilizer cost, contribute to increase profit for rice growing farmers. Therefore, it should be trained and widely spread to farmers in combination with IPM, high quality-rice-seed production, "three reductions, three gains" *etc.*

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Ảnh hưởng của biện pháp bón phân theo địa điểm đối với năng suất, hiệu quả và lợi nhuận cho sản xuất lúa ở đồng bằng sông Cửu Long

Thí nghiệm ngoài đồng áp dụng kỹ thuật lô khuyết (không bón phân) ngay trên 30 ruộng nông dân ở ba tỉnh Cần Thơ, An Giang và Tiền Giang so sánh và đánh giá hiệu quả của phương pháp bón phân theo địa điểm (SSNM) với phương pháp bón phân theo kinh nghiệm của nông dân (FFP) và khuyến cáo của khuyến nông (EFP) đến năng suất lúa và hiệu quả sử dụng phân bón đã cho thấy sự khác biệt về năng suất, hiệu quả sử dụng phân bón giữa ba phương pháp bón phân ở từng địa điểm cụ thể và mùa vụ là rất đáng kể. Năng suất lúa ở phương pháp SSNM đạt xấp xỉ hoặc cao hơn so với năng suất lúa ở các phương pháp EFP và FFP (cao hơn trung bình 0,17 tấn/ha). Phương pháp SSNM đã nâng cao hiệu quả sử dụng phân bón N, P, K. Các hiệu quả sử dụng phân bón AEN, REN, AEP, REP, AEK, REK đạt được đều cao hơn so với hai phương pháp EFP và FFP. AEN đạt được đối với SSNM là 12-17 kg lúa/kg N cao hơn so FFP từ 1,1-3,4 kg lúa/kg N. AEP đạt 25-46 kg lúa/kg P₂O₅ cao hơn FFP từ 2,6-7,7 kg lúa/kg P₂O₅, AEK đạt 2,4-13,4 kg lúa/kg K₂O cao hơn FFP từ 2,4-5,1 kg lúa/kg K₂O và đặc biệt hiệu quả thu hồi dinh dưỡng đạm khá cao, REN đạt từ 0,51-0,56, giúp tiết kiệm được một lượng phân bón đáng kể: SSNM đã giúp giảm được lượng phân đạm bón trung bình 11 kg N/ha; 5,2 kg P₂O₅/ha, và 16 kg K₂O/ha. Về hiệu quả kinh tế, SSNM giúp giảm chi phí phân bón từ 3,6 - 16,6%. Phương pháp SSNM đã góp phần tăng thu nhập, tăng lợi nhuận cho người trồng lúa thông qua giảm chi phí phân bón và gia tăng tỉ số lợi nhuận/chi phí phân bón. SSNM thật sự là một phương pháp bón phân hữu hiệu, cần được tập huấn và mở rộng thử nghiệm kết hợp trong các chương trình như "ba giảm ba tăng", nhân lúa giống chất lượng, IPM, v.v... để nông dân có thể ứng dụng trong sản xuất lúa hiệu quả.