SITE-SPECIFIC NUTRIENT MANAGEMENT FOR RICE IN THE MEKONG DELTA

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ABSTRACT

Farm monitoring for quantifying total and partial factor productivity (PFP) from fertilizers and other production inputs was conducted in rice farms at Omon, Cantho since 1995. Enormous variation in the indigenous N, P, and K supply was found among farmers' fields. Nitrogen fertilizer rates applied by the farmers varied greatly, but there was no relationship between the applied N rate and the indigenous N supply estimated by rice N uptake in 0N plots. Grain yield, agronomic efficiency and PFP of applied N were increased through a site-specific nutrient management (SSNM) approach, although the farmers also tended to improve their nutrient management practices by learning from the SSNM. The ability to adjust the quantity of applied fertilizers in relation to variation in the indigenous nutrient supply from the soil is proposed as a key component for achieving higher yields on a sustainable basis.

INTRODUCTION

There is great variation in the indigenous nutrient supply among soils within a rice growing domain, although the general perception used to be that irrigated ricelands are rather homogeneous in their natural resources. This variability depends on a number of factors, such as the method of land preparation, irrigation management practices, condition of the soil during fallow period, the activities of micro organisms in the soil, etc. (Cassman et al 1995, Kundu and Ladha, 1995), whereas fertilizer recommendation to rice are generally provided uniformly on provincial or regional basis. Therefore, grain yield and fertilizer use efficiency of farmers' fields, which followed the regional fertilizer recommendation, were lower than that achieved in research stations (Tan, 1996). At issue is whether a more site - (field-) specific recommendation for NPK fertilizer management will perform better over the short and long run than the current practices of rice farmers in the Mekong Delta.

The purpose of this study was to: (I) quantify the magnitude of variation in the indigenous nutrient supply; (ii) compare the productivity and nutrient efficiency of site-specific nutrient management (SSNM) and farmers' fertilizer practices (FFP) in intensive irrigated rice production systems in the Mekong Delta of Vietnam.

MATERIALS AND METHODS

On farm experiments were initiated in the dry season 1995 and have continued since then with two rice crops per year

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(dry and wet season) in the Omon district, Cantho province (10^o 34` N, $100^o$ 7`E, 3 m asl). The soil was classified as a Fluvaquentic Humaquept. It is a clayey soil with very slow infiltration, high water holding capacity and easy to puddle.

A total of 24 farmers' fields (32 in 1995-96) were selected from 6 villages in Omon district, Cantho province. All fields were direct-sown with high yielding rice. Farmers in this area do not apply basal fertilizer before or at sowing. The first fertilizer is usually applied at 7-10 d after sowing (about 1/3 of N, 2/3 of P). One third of N and the remaining P are applied at 25-30 d after sowing. The remaining N is applied at panicle initiation stage. Normally farmers did not apply K, only small amounts contained in combined NPK fertilizers. It should be noted, however, that there is wide variation in the fertilizer use patterns among the rice farmers, deviating much from the general recommendations.

Within each farmer's field, nutrient omission plots (no fertilizer, +PK, +NK, +NP) were established in 2-3 replicates per field. These plots serve the purpose of monitoring changes in indigenous N supply (=N uptake in –F or +PK plots) over time periods of 3-6 years and estimating the indigenous supply of P (=P uptake in +NK plots) and K (=K uptake in +NP plots). In the remainder of the field, farmers applied their own NPK management regime. Each -F, +PK, +NP & +NK plot was surrounded by a 20-cm high bund to minimize movement of applied N from the field at large. Farmers were responsible for all other crop management operations in the -F, +PK, +NP & +NK plots and in the field at large. Additional 6 x 6 m sampling areas adjacent to each of the -F, +PK, +NP & +NK plots were designated as a "Farmer Fertilizer Practice" (FFP plots). Researcher recorded the rates and timings of fertilizer application made by each farmer in these areas outside the -F, +PK, +NP & +NK plots.

An area of 300 m^2 was designated as a "Site-Specific Nutrient Management" (SSNM) plot, in which SSNM concept described by Dobermann & White (1998) is implemented. In this treatment, N, P & K fertilizers were applied to the plot following estimates of the indigenous supply of N, P and K obtained from the different treatments described above. In addition, N splitting and timing of split applications is fine-tuned using a SPAD chlorophyll meter. The location of this plot is fixed to evaluate the performance of SSNM over a period of at least six rice crops.

Plant measurement and samples for nutrient analysis were taken from all -F, +PK, +NP +NK, SSNM and FFP plots. The severity of weed infestation, diseases, insects damage were rated. Nitrogen, phosphorus and potassium were measured in the straw and grain at physiological maturity. Grain yields were measured from a sample area of 10 m^2 in each plot. Total N, P & K in above ground biomass were estimated from the oven-dry yield in 10 m^2 harvested area, then computed based on N, P & K concentration of grain and straw.

RESULTS AND DISCUSSION

Variation in grain yield and N uptake among farms were recorded in all five seasons (Table 1). Mean grain yield ranged from 2.49 to 5.70 t ha^{-1} for 1995 DS, 0.95 to 3.63 t ha^{-1} for 1995 WS, 2.27 to 5.42 t ha^{-1} for 1996 DS, 0.91 to 4.01 for 1997WS and 2.93 to 4.69 for 1998 DS in the plots without fertilizer application (-F). Similarly, N uptake in these plots varied from 27.7 to 82.4 & 7.7 to 48.1 for 1995 DS & WS, 25.9 to 75.1 kg ha-1 for 1996 DS, 14.4 to 64.1 for 1997 WS and 37.9 to 64.9 for 1998 DS. Even in the same village with similar soil types grain yield and N uptake in the -F plots varied widely. Similar ranges were observed for the indigenous supply of P and K (data not shown).

Table 1. Effect of fertilization and agronomic practices on grain yield and nitrogen uptake in on-farm experiments at Omon, Cantho (N=24-32 farms)

Season	Treat-ment	Grain yield (t/ha)			N-uptake (kg N/ha)		
		Mean	Min	Max	Mean	Min	Max
DS1995	-F	4.25	2.49	5.70	52	28	82
	+PK	4.64	2.99	5.90	55	35	77
	FFP	5.35	3.76	6.71	86	61	122
WS1995	-F	1.81	0.95	3.63	21	8	49
	+PK	2.29	1.31	3.94	28	14	53
	FFP	3.49	2.57	4.57	50	24	74
DS1996	-F	3.95	2.27	5.42	46	26	75
	+PK	4.49	3.18	6.63	53	30	86
	FFP	5.36	4.31	7.47	81	26	120
WS1997	-F	1.99	0.91	4.01	36	14	64
	+NP	3.30	1.59	5.22	65	36	104
	+NK	2.67	1.07	4.77	53	29	106
	FFP	3.46	1.54	5.58	68	32	118
	SSNM	3.60	1.80	5.29	68	28	105
DS1998	-F	3.72	2.93	4.69	51	38	65
	+NP	4.94	4.24	5.94	-	-	-
	+NK	4.79	4.08	5.57	-	-	-
	FFP	5.42	4.44	6.39	94	78	115
	SSNM	5.81	4.80	6.81	102	75	124

The N fertilizer rate applied by farmers was not related to the indigenous N supply from their soil. Generally, rice response to N applied was high in DS

and low in the WS, but the farmers in these areas applied more N fertilizer in

the WS than in the DS (Table 2). This was one of the reasons why N the use efficiency recorded in farmers' fields was low. Moreover, the grain yield increase due to N was not correlated with the N fertilizer rate applied by farmer.

The agronomic efficiency (AE N, kg grain yield increase/kg N applied) and partial factor productivity for N (PFP N, kg grain/kg N applied) achieved by farmer fertilizer practices (FFP) and by researchers (SSNM) are presented in Table 2. Mean AE N was 8-16 kg grain kg^{-1} N of applied N in all five crop seasons by farmers, whereas the AE was 15-23 kg grain kg^{-1} N of applied N in SSNM by researchers. The PFP N was higher in the SSNM as compared to the FFP plots. Strikingly, however, the average AE N in the FFP plots was only 8-10 kg grain/kg N during 1995-1996, but increased significantly to 13.2 kg/kg Before 1997, the farmers did not respond to differences in the indigenous N supply by adjusting the rate of applied N accordingly. Most of the farmers applied N fertilizer by looking at their crop with their own experiences. Normally, the WS crop looks poorer than the DS crop so that farmers seemed to be tempted to apply more N in the WS (Table 2), despite the low climatic yield potential and numerous crop management problems (weeds and other pests) that reduce WS yields much more than those in the DS. In the 1998DS, high recovery efficiency of applied N was achieved in SSNM (average 57%).

The more balanced nutrition (less N but more P and K applied, Table 3) and increased N uptake N efficiency in the 1997 WS and 16.6 kg/kg in the 1998DS crop. Apparently, with the start of the SSNM treatment farmers observed researchers' practices of N splitting and timing, resulting in the significant increase of N use efficiency after 1997. Moreover, farmers continuously increased their K fertilizer rates from 5.6 kg K/ha in the 1995DS to 20.7 kg K/ha in the 1998DS, leading to a more balanced nutrition as another factor for increasing N efficiency.

(Table2) lead to a significant increase in the average grain yield in the SSNM (5.8 t/ha) as compared to the FFP (5.4 t/ha) in the 1998DS (Table 1). However, yields in the 1998DS were somewhat reduced by a lower climatic yield potential, presumably increased spikelet sterility due to high temperatures at flowering, as can be deducted from significantly lower yields in the –F plots in 1998 (3.7 t/ha) compared to previous years (4-4.3 t/ha, Table 1). Therefore, there is scope for further yield increases beyond 6 t/ha through the SSNM approach. In the 1997WS, yields were generally low due to unfavorable climate and pest problems and differences between the SSNM and FFP were not significant (Table 1).

Table 2. Comparison of grain yield, N rate, recovery efficiency (RE), agronomic efficiency (AE) and partial factor productivity of applied nitrogen (PFP) between Farmers' Fertilizer practice (FFP) and the LTFE at Omon (1995-96) or FFP and the SSNM treatment in the on-farm experiments (1997-98) at Omon, Cantho.

Season	Item	Unit	FFP	*LTFE* or SSNM	Difference
DS1995	Grain yield	(t/ha)	5.35	*6.45*	*1.10* ***
	N rate	(kg/ha)	90	*100*	*10* ns
	RE N	%	36	-	-
	AE N	(kg/kg)	8	*20*	*12* ***
	PFP N	(kg/kg)	61	*65*	*4* ns
WS1995	Grain yield	(t/ha)	3.49	*3.54*	*0.43* ns
	N rate	(kg/ha)	123	*80*	*-43* ***
	RE N	%	18	-	-
	AE	(kg/kg)	10	*15*	*5* ***
	PFP N	(kg/kg)	30	*44*	*14* ***
DS1996	Grain yield	(t/ha)	5.36	*6.41*	*1.05* ***
	N rate	(kg/ha)	110	*100*	*-10* ns
	RE N	%	26	-	-
	AE	(kg/kg)	8	*23*	*15* ***
	PFP N	(kg/kg)	51	*64*	*13* ***
WS1997	Grain yield	(t/ha)	3.46	3.60	0.14 ns
	N rate	(kg/ha)	119	99	-20 ***
	RE N	%	29	32	3ns
	AE	(kg/kg)	13	16	3*
	PFP N	(kg/kg)	31	36	5 ***
DS1998	Grain yield	(t/ha)	5.42	5.81	0.39 *
	N rate	(kg/ha)	100	92	-8 ns
	RE N	%	43	57	14 ***
	AE	(kg/kg)	17	23	6 **
	PFP N	(kg/kg)	52	62	10 ***

*ns: not significant; ***: highly significant; FFP: Farmer fertilizer practice*

Table 3. Fertilizer use in Farmers' Fertilizer Practice FFP and Site Specific Nutrient Management (SSNM) treatments in on-farm experiments at Omon, Cantho (N=24-32 farms).

Season	Item	Unit	FFP	(Min-Max)	SSNM	(Min-Max)
DS 1995	N rate	(kg N/ha)	90.4	(47-123)		
	P rate	(kg P/ha)	12.1	(3-27)		
	K rate	(kg K/ha)	5.6	(0-23)		
WS 1995	N rate	(kg N/ha)	123.4	(77-177)		
	P rate	(kg P/ha)	19.3	(6-51)		
	K rate	(kg K/ha)	8.9	(0-21)		
DS 1996	N rate	(kg N/ha)	110.8	(78-182)		
	P rate	(kg P/ha)	19.5	(7-37)		
	K rate	(kg K/ha)	9.4	(0-36)		
WS 1997	N rate	(kg N/ha)	118.6	(72-190)	99.2	(75-118)
	P rate	(kg P/ha)	20.2	(0-33)	27.2	(10-45)
	K rate	(kg K/ha)	17.2	(0-58)	86.3	(37-116)
DS1998	N rate	(kg N/ha)	100.4	(75-137)	92.5	(63-127)
	P rate	(kg P/ha)	16.9	(4-35)	26.1	(10-40)
	K rate	(kg K/ha)	20.7	(0-70)	70.2	(30-106)

CONCLUSIONS

1. The nutrient-supplying capacity of lowland rice soils varies much from field to field, more than often assumed. Most research on improving N efficiency in lowland rice systems has focused on increasing AE N by improved timing, placement and formulation of applied N. In our study, however, the variation among farmers' fields in the Yo/Nr component of PFP N was equal to or greater than the variation in AE N.

2. General fertilizer recommendations for rice given for a large area (provincial or regional scale) have limited suitability for further increasing rice yields. For high yield levels, it is necessary to adjust fertilizer rates on a more site-specific basis.

3. Field-specific fertilization based on crop N status and soil nutrient supplying capacity led to significant increases in grain yields, nutrient uptake and N use efficiency, particularly in the DS. Climatic factors and the overall quality of crop management factors affected the response to nutrients in the SSNM approach. Opportunities for increasing WS yields through this approach appear more limited due to the generally low and varying climatic yield potential, often causing farmers to pay less attention to crop management.

4. The farmers participating in the RTDP project in the Mekong Delta

have started to change their fertilizer usage through learning-by-seeing, without any direct interference by the researchers. Better splitting and timing of N applications as well as a continuing increase in K fertilizer use have already lead to significant increases in N use efficiency and N uptake by rice as compared to 1995-1996.

5. Performance evaluation of the SSNM will continue in combination with IPM and using larger land units during 1999-2000, before it can enter an extension phase planned for 2001-2003.

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TÓM TẮT

Quản lý dinh dưỡng cho lúa ở vùng đồng bằng sông Cửu Long

Thí nghiệm đánh giá tổng quát và từng phần các yếu tố ảnh hưởng đến năng suất lúa được thực hiện tại Ô Môn, Cần Thơ từ năm 1995 đến nay. Khả năng cung cấp N, P và K biến động rất lớn giữa các thửa ruộng khác nhau. Lượng phân đạm các nông hộ bón cũng biến động rất lớn, nhưng lượng phân bón này không tương quan với khả năng cung cấp đạm của lô đối chứng không bón phân. So với bón phân theo kinh nghiệm của nông dân, năng suất lúa và hiệu quả sử dụng phân đạm gia tăng do áp dụng phương pháp bón phân theo từng thửa ruộng, mặc dù người nông dân đã cố gắng học hỏi để gia tăng năng suất theo kinh nghiệm của mình. Việc điều chỉnh lượng phân cho phù hợp theo khả năng cung cấp dinh dưỡng từ đất là yếu tố then chốt để đạt năng suất cao và ổn định