Farmer's Participatory Site Specific Nutrient Management in Tidal Flooded Soil for High Yielding Aus Rice

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ABSTRACT

Experiments were conducted in farmers' fields at Bakergonj, Barisal and Kathaltoli, Potuakhali districts to develop site-specific nutrient management package for high yielding aus rice. The participating farmers delineated soil fertility as the most fertile (grade I), medium fertile (grade II) and the least fertile (grade III) soil. Omissions of N, P, and K were compared with added NPK fertilizers in different fertility grades. At Bakergonj, the NPK treat plots yielded 4.29, 4.36 and 2.09 t ha – 1 in soil grade I, II and III, respectively. Omission of N, P and K reduced grain yield by 0.76, 0.95 and 0.29 t ha^{-1} in grade I, 1.53, 0.87 and 1.25 t ha^{-1} in grade II and 0.64, 0 and 0.28 t ha^{-1} in grade III, respectively. At Kathaltoli, the grain yield (6.21 t ha^{-1}) in grade I was higher than grade II (5.58 t ha^{-1}) and grade III (5.11 t ha^{-1}). Omission of N, P and K reduced grain yield by 0.93, 0.18 and 0.09 t ha^{-1} in grade I, 1.30, 0.37 and 0.93 t ha^{-1} in grade II and 1.86, 1.30 and 1.30 t ha^{-1} in grade III, respectively. For Bakergonj, the calculated optimum doses of N were 34, 69 and 29 kg ha^{-1}, P were 4.0, 4.0 and 0.0 kg ha^{-1} and K were 7.0, 31.0 and 7.0 kg ha^{-1} for fertility grade I, II and III, respectively. For Kathaltoli, the calculated optimum doses of N were 42, 59 and 84 kg ha^{-1}, P were 1.0, 2.0 and 5.0 kg ha^{-1} and K were 2.0, 23.0 and 33.0 kg ha^{-1} for fertility grade I, II and III, respectively. The application of predicted fertilizer dose might increase rice yield in all fertility grades of soil in both the locations.

Key words: Soil fertility grade, fertilizer dose, grain yield, relative yield.

INTRODUCTION

Nitrogen, P and K are often applied to plants to ensure economically viable grain yields in large-scale cropping systems (Swanson, 1982, Mengel, 1990). The use of site-specific nutrient management has been shown to be a simple and effective way to increase N use efficiency (Khosla *et al.,* 2002, Hornung *et al.,* 2006). In China, site-specific nutrient management increased rice yield to 6.4 t ha^{-1} from the 5.9 t ha^{-1} which was obtained with the farmers' fertilizer management (Wang *et al.,* 2001). Native soil fertility may be determined effectively by the nutrient omission plot technique (Chowdhury *et al.,* 2007, Khatun and Saleque, 2010). With trial and error experience, the farmers generally know which area of a field is more productive than the others and accordingly assess nutrient needs for different parts of a field (Saleque *et al.,* 2005). Farmers' experience on village level soil fertility gradients agreed well with soil test results (Saleque *et al.,* 2005, Kabir *et*

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al., 2007, Biswas *et al.,* 2007, Maniruzzaman *et al.,* 2008). However, farmers' perception on soil-fertility is not recognized.

In a densely populated country like Bangladesh, farmer's experience of soil fertility variations within the village would have a great contribution in crop and soil research. Field specific nutrient management has the potential to be an effective alternative to grid soil sampling for quantifying and managing the spatial variability for fertilizer recommendation (Fleming *et al.,* 2000, Khosla *et al.,* 2002). Differential nutrient management by the owners and fertility differences due to micro topography among plots have made it difficult to prescribe a uniform rate of fertilizer for a wide area without consulting with the farmers. Though farmers' perceptions about soil fertility are not acknowledged in Bangladesh, they are well experienced about their land fertility and productivity and accordingly, they manage the nutrient needs of their land. However, it was hypothesized that improved nutrient management package can be developed in the form of village-level soil-fertility maps based on farmers' perceptions. The present study was therefore, undertaken to recognize spatial variability in soil-fertility in rice fields and develop a field-specific nutrient management package for Aus rice in a village of tidal ecosystems.

MATERIALS AND METHODS

The experimental sites fall under the agro-ecological zone 13 located at Dodul Mow village in Bakergonj upazilla (N 32◦ 24' 43" E 20◦ 01' 00") under Barisal district and Kathaltoli, Mirjagonj Upazilla under Potuakhali district. T. Aus–T. Aman–Fallow is the dominant cropping system in those villages for last 40 years. T. Aus is grown during April to July using both high yielding and local rice varieties. The study was conducted during Aus season, 2009 at different soil fertility grades.

Soil fertility grades at village levels were assessed through participatory soil fertility appraisal (Saleque *et al*., 2005). A farmers meeting with 10 participants were held at each village, representing Aus growing area. The farmers were asked to provide information on village boundaries, yield performance of rice in different fields of the village, rice varieties grown and fertilizer uses. The participating farmers sketched a village map, delineating crop fields and uncultivable area. After completion of village map, they sketched a field map and we facilitated the drawing of sub-field boundaries. Each sub-field was occupied several individual plots. The participating farmers divided the entire field into three fertility grades based on yield history and they marked the soil as grade-I, grade-II and grade-III for most fertile, fertile and the least fertile, respectively. They grow BR12, BR2 (Mala) and Monsur IRRI, a locally named HYV were during the Aus season.

All the fields in the village were tidal flooded during the crop season (tidal water depth was 40-70 cm). Rice seedlings of 25-30 days were transplanted during 5-15 in 2009. Three plots in each soil fertility grade were selected in each site. Each farmer's field represented one replication. The experimental design was a randomized dispersed block. In each farmer's field four treatments: NPK, –N, –P and –K were applied. A portion of 10×10 m^2 area from each field was separated by bund and that portion was equally divided to accommodate four treatments.

Soil samples were collected from different plots of variable fertility levels and were analyzed and the initial soil nutrient status has been presented in Table 1. Soil test-based (STB) recommended doses were applied in different gradient of plots (Table 2). Required amounts of N, P and K were applied as urea, TSP and MP, respectively, as per treatment. Full dose of TSP and MP were applied during final land preparation and urea was applied after 15 and 30 days after transplanting at Bakergonj whereas urea super granules (USG) was applied at Kathaltoli.

Table 1. Chemical properties of initial soil in different fertility grades collected from farmers' field at Bakergonj and Kathaltoli, Aus 2009

Site	Fertility Grade	P^H	Organic matter (%)	Total N (%)	P (ppm)	K (m mol / 100 g soil)
	I	6.65	1.65	0.096	2.4	0.21
Bakergonj	II	5.69	1.94	0.113	1.2	0.22
	III	7.22	1.94	0.113	3.1	0.26
	I	4.70	1.94	0.113	2.5	0.30
Kathaltoli	II	4.40	2.25	0.131	1.5	0.28
	III	4.67	2.46	0.143	3.4	0.29

Table 2. Fertilizer doses applied in different soil grades at farmers' field, Aus, 2009

Site	Soil fertility grade	Fertilizer dose (kg ha^{-1})		
		N	P	K
	I	88.0	21.6	21.6
Bakergonj	II	82.4	22.8	19.2
	III	82.4	20.9	9.6
	I	82.4	21.5	0
Kathaltoli	II	76.4	22.5	4.8
	III	72.4	20.6	2.4

Relative yield were estimated by using the formula:

Optimum N, P and K doses were calculated following the formula as described by Driessen (1986).

$$N = \frac{\text{(Yield in NPK plots – yield in N omission plot)}}{\text{N use efficiency}} \times 18$$

$$P = \frac{\text{(Yield in NPK plots – yield in P omission plot)}}{\text{P use efficiency}} \times 2.5$$

$$K = \frac{\text{(Yield in NPK plots – yield in K omission plot)}}{\text{K use efficiency}} \times 20$$

The participating farmers conducted all the field operations. Data on grain yield was recorded from the harvest area of 5 m^2 per plot and converted into ton per ha. The grain yield was expressed in t ha^{-1} at 14% moisture level.

RESULTS AND DISCUSSION

Grain yields in the NPK treated plots in soil fertility grade I, II and III were 4.29, 4.36 and 2.09 t ha^{-1}, respectively at Bakergonj and 6.51, 6.23 and 6.23 t ha^{-1}, respectively at Kathaltoli (Table 3). The yields in soil fertility grades I and II were higher than grade III at Bakergonj but not at Kathaltoli. In each omission treatment, yield difference between fertility grades was significant in both locations; however, magnitude of the difference between nutrient treatments in different fertility grades was not similar. In soil grade I, the grain yield of NPK treated omission of N, P and K plots were 4.29, 3.53, 3.34 and 4.00 t ha^{-1}, respectively at Bakergonj and 6.51, 5.58, 6.33 and 6.42 t ha^{-1}, respectively at Kathaltoli. The highest yield was obtained from NPK treated plot followed by P and K omission plots and the lowest was from N omission plot. Differences between –N, –P and –K plots were insignificant. In soil fertility grade II, NPK treated plot gave the highest grain yield (4.36 t ha^{-1}) followed by P and K omission plots (3.49 and 3.11 t ha^{-1}, respectively) and the lowest (2.83 t ha^{-1}) was observed in N omission plot at Bakergonj. But at Kathaltoli, the highest grain yield was obtained in NPK treated plots (6.43 t ha^{-1}) followed by P and K omission plots (5.86 and 5.30 t ha^{-1}). Similarly, in soil fertility grade III, the grain yield of NPK, omission of N, P and K plots were 2.09, 1.45, 2.63 and 1.81 t ha^{-1}, respectively in Bakergonj and 6.23, 4.37, 4.93 and 4.93 t ha^{-1}, respectively at Kathaltoli. As a whole, the yield at Kathaltoli was much higher compared to Bakergonj. It is noteworthy here that farmers at Kathaltoli applied N through USG deep placement. Native soil fertility of Kathaltoli was better than Bakergonj site (Table 1).

Table 3. Yield of rice as affected by different nutrient management practices and farmers defined soil fertility grades at farmers' field, Aus, 2009

Site	Soil fertility grade	Grain yield (t ha^{-1})			
		NPK	– N	– P	– K
Bakergonj	I	4.29	3.53	3.34	4.00
	II	4.36	2.83	3.49	3.11
	III	2.09	1.45	2.63	1.81
Kathaltoli	I	6.51	5.58	6.33	6.42
	II	6.23	4.93	5.86	5.30
	III	6.23	4.37	4.93	4.93

Relative yield in N omission plot compared to NPK plot was 82% in grade I, but in grade II and III it was 35 and 69%, respectively at Bakergonj. At Kathaltoli, there were 86, 79 and 70%, respectively (Table 4.). Relative yield of P omission plot varied from 78% in soil fertility grade I to 126% in soil fertility grade III at Bakergonj and 97% in fertility grade I to 79% in fertility grade III. However, in case of K omission plot, the lowest relative yield of 71% was found in soil fertility grade II and the highest of 93% in soil fertility grade I at Bakergonj and lowest 79% in fertility grade III and highest 99% in grade I at Kathaltoli.

Table 4. Relative yield of rice in N, P and K omission plots under different soil fertility grades at farmers' field, Aus, 2009

Site	Soil fertility grade	Relative yield (RY) (%)		
		– N	– P	– K
Bakergonj	I	82	78	93
	II	35	80	71
	III	69	126	87
Kathaltoli	I	86	97	99
	II	79	94	85
	III	70	79	79

The optimum doses of N, P and K were calculated which were 18, 2.5 and 20 kg N, P and K to produce one ton of rice using secondary data of N, P and K requirement (Dobermann and White, 1999) for rice and apparent recovery data (40, 60 and 80% for N, P and K, respectively) (BRRI, 2004). The calculated optimum doses of N for soil grade I, II and III were 34, 69 and 29 kg ha^{-1}, P doses were 4, 4 and 0 kg ha^{-1} and K dose would be 7, 31 and 7 kg ha^{-1} for Bakergonj soil (Table 5).

But the calculated optimum dose for N, P, K in fertility grade III supposed to be higher. For Kathaltoli, there were 42, 59, and 84 kg N ha^{-1}; 1, 2 and 5 kg P ha^{-1} and 2, 23 and 33 kg K ha^{-1} for grade I, II and III, respectively.

Table 5. Calculated optimum dose of different nutrients under different soil fertility grades at farmers' field, Aus, 2009

Site	Soil fertility grade	Calculated optimum dose (kg/ha)		
		N	P	K
	I	34	4	7
Bakergonj	II	69	4	31
	III	29	0	7
	I	42	1	2
Kathaltoli	II	59	2	23
	III	84	5	33

Farmers generally apply urea 50-60 kg N ha^{-1} only for HYVs in Aus season but they do not apply P and K fertilizers because their lands become flooded with tidal water and significant amount of P and K elements are added in their soil as tidal sediment (BRRI 2009). Here, the calculated optimum N and P doses for different soil grades are much less than the soil test based doses. But the calculated K doses are much higher than soil test base (STB) doses for Kathaltoli. BARC recommendation for K fertilizer also differs with farmers' applied and calculated optimum dose. Imbalanced fertilizer application during rice cultivation will make depletion of soil nutrients leading to production decline as well as to deterioration of soil physical and chemical properties. In order to sustain agricultural production, it is important to maintain these soil physical and chemical properties by applying optimum dose of fertilizer.

The field specific nutrient management for the participating farmers would be useful in the future for the specific village. In that village, the farmers may also apply the field-specific nutrient management dose, as the fertility grade is already delineated. The micro topography and soil quality determined by indigenous tools may help identify the soil-fertility-grade specific nutrient management for the neighboring villages. The implication of this participatory research is that the farmers can decide how much fertilizer would be needed for a specific soil fertility grade. Research and extension activity at the farm level may simultaneously proceed, which may help increase yields. Adoption of farmers' participatory fertility-grade-specific nutrient management program may significantly contribute to the national target of a 25% food grain increase in Bangladesh by 2015 (Saleque *et al.,* 2008).

CONCLUSIONS

In this study, grain yield and optimum dose of nutrients across the farmers' fields showed spatial variability. The application of appropriate fertilizer dose may increase rice yield in all fertility grades of soil to a certain level, which is possible with farmers' present level of knowledge and minimize cost.

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