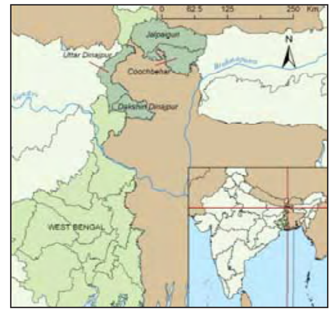
Response of Rainfed Rice to Soil Test-Based Nutrient Application in Terai Alluvial Soils



By D. Mukhopadhyay, K. Majumdar, R. Pati, and M.K. Mandal

Results of 2 years of field experiments evaluating the impact of soil test-based fertilization on rainfed rice showed significant yield increase with balanced use of nutrients. Omission of nutrients caused yield loss between 33 to 50% (- P), 20 to 32% (- K), 15 to 28% (- S), 33 to 35% (-Zn), and 31 to 34% (- B) in the Terai alluvial soils of West Bengal. Uptake of all the nutrients significantly correlated with yield, suggesting interdependence of nutrient uptake that influenced yield. Agronomic efficiency of P and K improved with 25% application of the nutrients over the optimum treatments. Recovery efficiency followed the same trend for all the nutrients studied.

Rice is one of the major crops in the northern districts of West Bengal. A little over 45% of the gross cropped area in the Terai alluvial zone of West Bengal is shared by Kharif (winter) rice. Existing statistics show that the productivity of rice in these districts…about 1.6 metric tons/hectare (t/ha) is considerably lower than the average productivity of 2.3 t/ha in the State. Uninterrupted rainfall during a part of monsoon months, occasional dry spells at flowering, a larger presence of local varieties in the field, and low level of fertilizer use are all reported to be important constraints to improved yields in the zone (Anonymous, 1989).

Soils of the Terai alluvial zone are typically deficient in several plant nutrients. Soil samples analyzed from the districts of Jalpaiguri, Coochbehar, Uttar Dinajpur, and Dakshin Dinajpur under Teesta-Terai alluvium showed that nearly 80% of soils fall under the low to medium category of N and K, while 60% of soils are low to medium in P (Ali, 2005). Availability of P and B are among the important nutrient related constraints in these soils. Soils of the Terai region are mostly acidic in reaction and contain high amounts of Fe and Al oxides and hydroxides. Fixation of applied P by such oxides and hydroxides is a common problem that hinders uptake of P by crops. Awareness about appropriate P application rates for rice in such soils among the farmers is critical to improve productivity. Deficiency of B in these soils is well recognized. Light textured soils and high rainfall (3,000 mm/year) in the region are contributing factors for B deficiency and most crops show distinct response to B application in these soils (Shukla et al., 1983; Saha, 1992). This zone of moderately leached coarse soils with poor fertility status offers scope to improve rice productivity through appropriate nutrient management. The present study was initiated to evaluate the effect of soil test-based fertilizer recommendation on winter rice and to identify the impact of nutrient omission from the recommended fertilizer schedule.

Researcher at rainfed rice plots.

The field experiments were conducted at the University farm, Pundibari, West Bengal, for two consecutive winter rice seasons. Random soil samples (0 to 15 cm) were collected from the experimental field, which remained fallow for the two previous years, before the start of the experiment for analysis following the Agro Services International (ASI) analytical methods (Portch and Hunter, 2002). Soils of the experimental plots were slightly acidic (pH 5.5 to 6.4) and sandy loam in texture with low status of the available N, P_2O_5, and K_2O (211, 11.4, and 95 kg/ha, respectively). The content of S (33.7 kg/ha) and Zn (1.25 kg/ha) was quite high in terms of the critical limit, while extractable B (0.28 kg/ha) was low in these experimental soils. A yield target-based recommendation was developed for rice cultivar IET-1444 (Khitish) following the ASI method. The experiment was laid out in a randomized block design with 12 treatments and four replications. The treatments were based on the full soil test-based fertilizer recommendation of 130 kg N, 100 kg P_2O_5, 100 kg K_2O, 35 kg S, 8 kg Zn, and 1.5 kg B per ha and was considered as optimum (OPT). The first six treatments included the optimum and subsequent omission of P, K, S, Zn, and B from the optimum rate. The second six treatments consisted of 125% of the OPT treatment where three major nutrients were applied at 25% higher than that of the optimum rate, keeping S, Zn, and B at the 100% level. The rest of the five treatments are omission treatments as described earlier. Uniform cultural practices and plant protection measures were used in all treatments. The basal fertilizer application included 25% of the total N and 100% of the P, K, S, Zn, and B. The first topdressing with 50% N was done 21 days after transplanting and the remaining N was applied at tillering stage. No organic amendments were applied prior to the sowing of the crop. Harvesting was done at maturity in the area marked in each plot, and treatment-wise yield and yield components were recorded.

The soil and plant samples at harvest were analyzed for nutrient concentration and uptake at maturity following standard procedures (Jackson, 1967), as were the residual soil nutrient content for each respective treatment.

Abbreviations and notes for this article: N = nitrogen; P = phosphorus; K = potassium; S = sulphur; Zn = zinc; B = boron; Fe = iron; Al = aluminum.

The average two season grain and straw yield of rice (Cv. Khitish) varied from 2,010 to 3,990 kg/ha and 4,390 to 8,000 kg/ha, respectively (**Table 1**). Maximum grain yield of rice was obtained at 125% of the optimum application rate. The straw yield was also highest in this treatment, followed closely by the 100% nutrient application. Omission of nutrients from the optimum treatment caused yield losses that varied between 20 to 35% (**Table 1**). Yield was strongly influenced by exclusion of Zn, B, and P that caused comparable yield losses (34%). Yield loss was much higher with omission of nutrients from the 125% OPT treatment and varied between 15 to 50%. Yield loss was highest in the OPT-P plot (50%), followed by more than 30% yield losses due to exclusion of Zn, K, and B from the OPT treatment. The yield data revealed that P, Zn, and B are the main limiting factors under the present experimental set up. Exclusion of nutrients from the optimum treatment did not influence the harvest index (**Table 1**).

Table 1. Effect of nutrients on grain and straw yield of rice, Pundibari, West Bengal.

Treatments	Grain yield, kg/ha	Straw yield, kg/ha	Δ Yield, kg/ha	Harvest index
OPT	3,760	7,690	–	0.33
OPT-P	2,530	5,310	1,230 (33)	0.32
OPT-K	3,010	6,140	750 (20)	0.33
OPT-S	2,710	5,950	1,050 (28)	0.31
OPT-Zn	2,450	5,120	1,310 (35)	0.32
OPT-B	2,490	4,760	1,270 (34)	0.34
125% OPT	3,990	8,000	–	0.33
125% OPT-P	2,010	4,390	1,980 (50)	0.31
125% OPT-K	2,700	5,450	1,290 (32)	0.33
125% OPT-S	3,380	7,030	610 (15)	0.33
125% OPT-Zn	2,680	5,710	1,310 (33)	0.32
125% OPT-B	2,750	5,880	1,240 (31)	0.32
CD (p=0.05)	18	10	–	–

Δ Yield = Yield of OPT- yield of omitted nutrient treatment; Data in parentheses are percent yield loss.

The average uptake of nutrients of rice (Cv. Khitish) varied from 74 to 130 kg/ha for N, 17 to 45 kg/ha for P_2O_5, 86 to 169 kg/ha for K_2O, 10 to 27 kg/ha for S, 5 to 18 kg/ha for Zn, and 0.02 to 0.08 kg/ha for B. The mean yield of rice for two seasons was significantly correlated with the uptake of all the nutrients (**Figure 1**). This suggests interdependence of uptake of a particular nutrient on the other applied nutrients, which ultimately influences yield. Such high correlation between yield and uptake of nutrients corroborates the importance of soil test-based nutrient application in kharif rice. The range and mean values for nutrient uptake per tonne of grain are provided in **Table 2**.

Table 2. Nutrient uptake expressed as kg/t of hybrid rice grain, Pundibari, West Bengal.

	N	P_2O_5	K_2O	S	Zn	B
Min	29.0	8.4	32.1	4.0	1.8	0.01
Max	38.9	12.5	46.5	8.0	4.5	0.02
Mean	34.3	9.9	39.8	6.0	3.0	0.01

Nutrient use efficiency can be expressed through agronomic efficiency (AE) and crop recovery efficiency (RE) (Fixen, 2005). Agronomic efficiency refers to the crop yield increase per unit of applied nutrient while recovery efficiency highlights the increase in plant nutrient uptake per unit of nutrient added. AE and RE were used in this experiment to assess the impact of soil test-based nutrient application and the effect of excluding nutrients from fertilization schedule (**Table 3**).

Table 3. Nutrient use efficiency of P, K, S, Zn, and B, Pundibari, West Bengal.

Parameters	Base treatment	P_2O_5	K_2O	S	Zn	B
Agronomic efficiency, kg/kg	OPT	12	8	30	164	850
	125% OPT	20	13	17	164	827
Recovery efficiency, %	OPT	24	52	19	49	2
	125% OPT	26	84	35	165	4

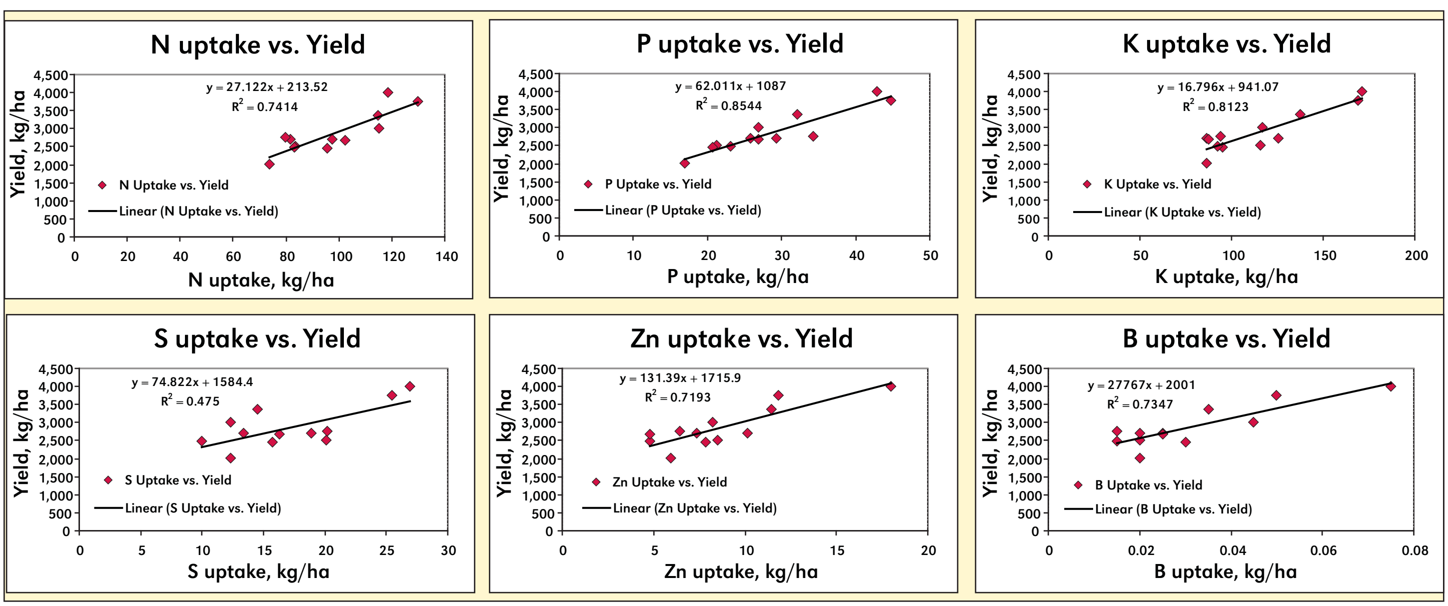


Figure 1. Interrelation between grain yield and uptake of nutrients in IET 1444, Pundibari, West Bengal.

Uptake of nutrients in plots correlated with yield, suggesting interdependence that influenced yield.

Both the efficiency parameters were compared with reference to the OPT and 125% OPT treatments. Agronomic efficiency of P and K improved with a 25% increase in application rates of these nutrients. Applying S at the 100% level, along with the 125% level of other macronutrient application rates, decreased the AE, while under a similar situation the AE of Zn and B remained unchanged. Recovery efficiency of all the nutrients increased considerably with the 125% OPT treatment.

From the results of the experiment, it was quite apparent that soil-test and yield target-based nutrient recommendation could help improve rainfed rice yield under the Terai alluvial situation of West Bengal. The experimental results showed that secondary (S) and micronutrients (B, Zn) had a significant influence on yield. This suggests that any productivity improvement effort in rainfed rice will need to take into account the effect of all limiting nutrients for a successful yield maximization program. Insufficiency of any of the studied nutrients in the fertilization schedule will cause considerable yield loss and subsequent loss of profit by the farmer. The best combination of nutrients for maximizing rainfed rice yield in the Terai alluvial situation is now being tested in farmers' fields to assess its effectiveness to improve yield and profit over traditional practices. BC

Dr. Mukhopadhyay is an Associate Professor in the Department of Soil Science and Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, West Bengal; e-mail: dibsm1@yahoo.co.in. Dr. Majumdar is Deputy Director, IPNI-India Program-East Zone; e-mail: kmajumdar@ipni.net. Mr. Pati (e-mail: rajibpati@gmail.com) and Mr. Mandal (e-mail: mkmskm2@rediffmail.com) are Research Fellows of UBKV.

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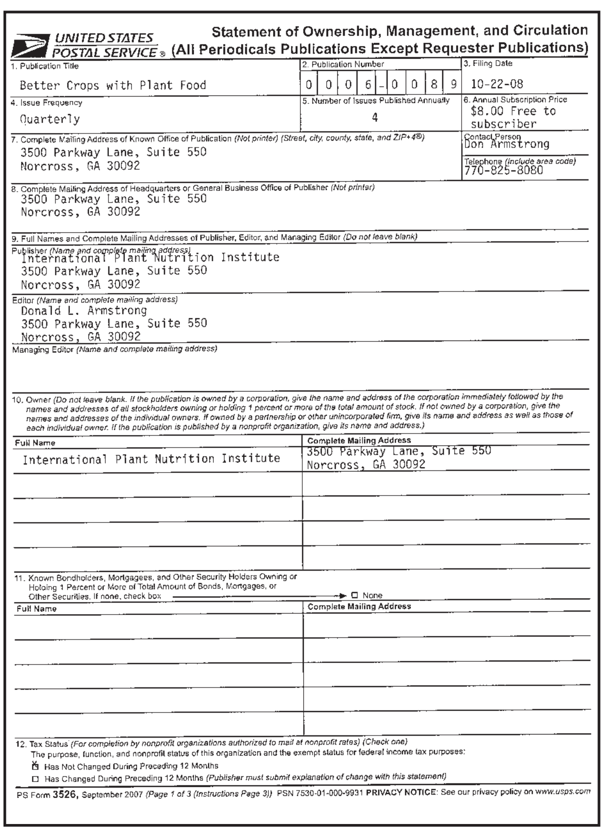

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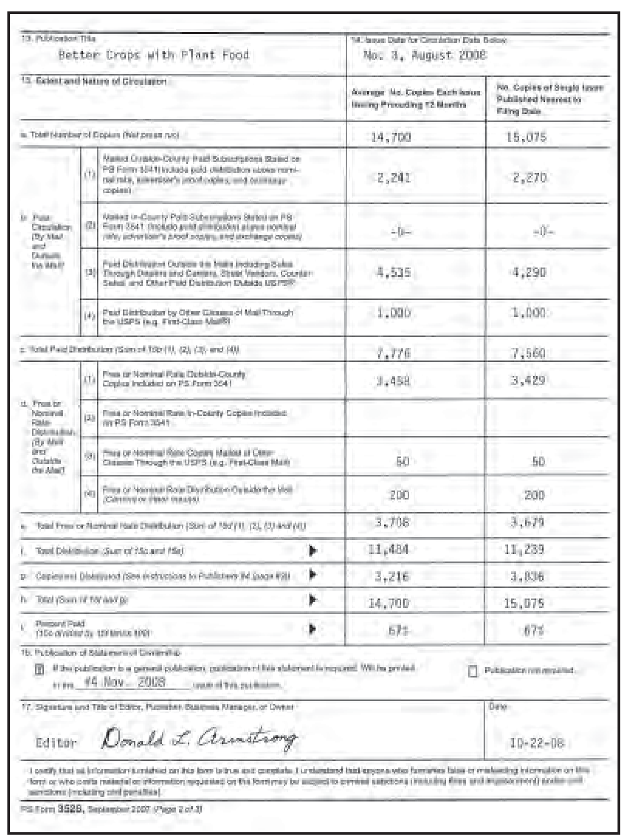

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