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Futile Integrated Nutrient Management in Azmiriganj Series for Boro Rice Cultivation

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ABSTRACT

The experiment was conducted at Bangladesh Rice Research Institute (BRRI) regional station farm, Habiganj, in Boro 2016-17 to observe the effect of integrated nutrient management (INM) on growth, yield, yield parameters and nutrient uptake of BRRI dhan29 in the haor soil. The experimental field belongs to the Azmiriganj series, under the agro-ecological zone 'Sylhet Basin' (AEZ-21). The experiment was designed with six treatments, including T_1 = Fertilizer control, T_2 = Recommended chemical fertilizer dose (N-P-K-S-Zn @ 130-18-60-13-4 kg ha^{-1}, respectively), T_3 = Cowdung (CD) @ 2 t ha^{-1} + 50% recommended chemical fertilizer, T_4 = CD @ 3 t ha^{-1} + 50% recommended chemical fertilizer, T_5 = CD @ 4 t ha^{-1} + 50% recommended chemical fertilizer, and T_6 = 120% of recommended chemical fertilizer dose. The experiment was laid out in an RCB design with 3 replications using the test crop BRRI dhan29. Application of CD @ 2, 3 or 4 t ha^{-1} with 50% recommended chemical fertilizer did not exceed the grain yield, yield parameters and nutrient uptake over recommended sole chemical fertilizers. The recommended dose of chemical fertilizer performed better than INM treatments in terms of yield and nutrient uptake in the haor area of the BRRI Habiganj farm.

Keywords: Integrated nutrient management, Cowdung, grain yield, nutrient content, nutrient uptake.

INTRODUCTION

Haor, a bowl-shaped, low-lying single rice ecosystems in north eastern Bangladesh, occupy about 0.68 million hectares (Huda, 2004). There are as many as 373 haors of variable sizes in Bangladesh, mostly cultivated with Boro rice during November – May. Haor soils usually show better rice productivity than that obtained with other soils. Grain sterility due to cold injury and early flash floods are the main climatic hazards in the haor regions. Farmers obtain a good rice yield in the haor with their own fertilizer management, provided there are no climatic difficulties.

Farmers in the haor region usually apply inorganic fertilizers to their Boro rice fields for a long time. The use of inorganic fertilizer in rice cultivation in Bangladesh has been progressively increasing in the haor areas. Expenditure for inorganic fertilizer is high, and thus, identifying appropriate and economically feasible approaches, which are environmentally friendly and healthy, is imperative. The use of inorganic fertilizer to sustain cropping was found to increase yield only for a few years, but in the long-term, it has not been effective and leads to soil degradation (Satyanarayana *et al.*, 2002). On the other hand, continuous application of organic fertilizer alone on the rice field, resulting low yield and low N and K content at the mid-tillering stage of the rice plant. This implies the need for integrated nutrient management for rice production. Therefore, the combined use of organic manures and inorganic fertilizers helps in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients,

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enhancing efficiency of applied nutrients and providing favorable soil physical conditions (Gill and Walia, 2014). Integrating nutrient management (INM) aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner (Farouque and Takeya, 2007). When used in combination, interactions occur, and the yield increase is always more than that from the use of equivalent quantities of these nutrient sources alone. Such integrated applications have proved to be complementary and synergistic. The most important methods to establish a relevant INM are: to ensure a balance plant nutrient supply from organic and inorganic sources, and to improve plant nutrient efficiency to optimize crop production and avoid nutrient losses. In this region, farmers seldom use organic manure, and they do not practice balance fertilization. Besides balanced fertilization, integrated nutrient management (INM) practice may be a good option for increasing rice yield. Considering the above context, the study was undertaken to observe the effect of INM practices on the grain yield of the Azmiriganj soil series of the single-cropped Boro area.

MATERIALS AND METHODS

The experiment was conducted at the BRRI regional station farm, Habiganj, in Boro (dry season rice) 2016-17. The experiment was conducted on Azmiriganj silty clay loam soil, a member of Baniachong group. The experimental field soil had soil pH 4.65, organic carbon 2.27%, total N 0.13%, available P 9.5 mg kg-1 (Bray and Kurtz Method; 0.03N NH4F+0.025 HCl (acidic soils, <pH 6.0) and exchangeable K 0.12 meq/100 g soil. Six different treatment combinations were considered for executing the experiment objectives. Treatments were T_1= Fertilizer control, T_2= Recommended chemical fertilizer dose (N-P-K-S-Zn @ 130-18-60-13-4 kg ha^{-1}, respectively), T_3= Cowdung (CD) @ 2 t ha^{-1} + 50% recommended chemical ferttilizer, T_4= CD @ 3 t ha^{-1} + 50% recommended chemical ferttilizer, T_5= CD @ 4 t ha^{-1} + 50% recommended chemical ferttilizer, and T_6= 120% of recommended chemical fertilizer dose. The experiment was laid out in an RCB design with 3 replications. The tested rice variety was BRRI dhan29. In Boro season, N-P-K-S-Zn @ 130-18-60-13-4 kg ha^{-1}, respectively, were used as BRRI recommendation. Well decomposed cowdung was applied at final land preparation in the respective plots with an appropriate dose as sundry basis moisture content (65%) and incorporated in the field properly. All chemical fertilizers except urea were applied as basal during final land preparation. Urea N was applied in equal 3 splits, i.e., one-third at 14 days after transplanting, one-third at the active tillering stage (44 days after transplanting) and one-third at 5 days before the panicle initiation stage of rice. The tested cropping pattern was Boro-Fallow-Fallow using BRRI dhan29 as a test variety. The unit plot size was 5m × 3m. Forty-five-day-old 2-3 seedlings $hill^{-1}$ were transplanted in 20 cm × 20 cm spacing. Irrigation and other management practices were done as per needed. The crop was harvested from 5 m^2 area at the center of each plot, and rice grain yield was adjusted to 14% moisture content and straw yield was oven-dry basis. The chemical analysis of plant samples was done in the Soil Science Division's laboratory, BRRI, Gazipur. All data were statistically analyzed by the software STAR.

RESULTS AND DISCUSSION

Shoot yield of Boro rice at panicle initiation (PI) stage

The shoot yield at panicle initiation (PI) stage increased significantly with application of chemical fertilizer and organic manure over fertilizer control treatment (Table 1). The highest shoot yield was obtained with the application of 120% chemical fertilizer followed by 100% recommended dose of chemical fertilizer. Statistically similar shoot yield was observed with the application of cowdung @ 2, 3 or 4 t ha^{-1} with 50% recommended chemical fertilizer. The fertilizer control plot gave the significantly lowest shoot yield.

Nutrient uptake at panicle initiation (PI) stage

The N, P, and K uptake by rice shoots at the PI stage was significantly influenced by practicing integrated nutrient management in Boro rice (Table 1). The highest N uptake was obtained with 120% chemical fertilizer treatment, followed by 100% chemical fertilizer treatment. Application of 2 or 3 ton CD ha^{-1} with 50% chemical fertilizer showed significantly lower N uptake than 100% recommended chemical fertilizer treatment, and statistically similar N uptake was found with application of 4 t CD ha^{-1} with 50% chemical fertilizer treatment and application of 100% recommended chemical fertilizer treatment. The lowest N uptake was observed in the fertilizer control treatment. The highest P uptake at the PI stage was found in 120% chemical fertilizer treatment, followed by 100% recommended chemical fertilizer treatment and the CD treated plots. Significantly lowest P uptake was found in the control treatment. The K uptake was higher in the application of 4 t CD ha^{-1} with 50% chemical fertilizer treatment, followed by the application of 3 t CD ha^{-1} with 50% chemical fertilizer treatment. But K uptake was statistically insignificant with the application of sole chemical or chemical plus organic matter treated plots. The K uptake was significantly lower in fertilizer control treatment (Table 1). Yamakawa et al. (2004) found that rice plants at the panicle initiation stage contain 2.27% N, 0.40% P and 3.05% K, which certainly endorses the findings of the present study.

Table 1. Effects of integrated nutrient management on shoot yield and nutrient uptake at panicle initiation stage of BRRI dhan29, BRRI farm, Habiganj, 2016-17.

Treatments	Shoot yield (t ha^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1	3.71	24.54	10.01	74.88
T_2	5.74	76.51	21.64	127.43
T_3	5.50	56.52	18.53	129.42
T_4	5.55	62.20	19.32	134.68
T_5	5.61	66.12	20.25	138.06
T_6	5.80	79.69	22.41	130.83
$LSD_{0.05}$	0.94	12.45	3.97	30.88
CV (%)	9.80	11.20	11.70	13.90

T_1=Fertilizer control, T_2=Recommended chemical fertilizer dose (N-P-K-S-Zn @ 130-18-60-13-4 kg ha^{-1}, respectively), T_3=Cowdung (CD) @ 2 t ha^{-1} + 50% rec. che. fert., T_4=CD @ 3 t ha^{-1}+ 50% rec. che. fert., T_5=CD @ 4 t ha^{-1}+ 50% rec. che. fert. and T_6=120% of recommended chemical fertilizer dose.

Yield and yield parameters of Boro rice

The application of integrated nutrient management (INM) increased tiller and panicle numbers compared to the control plot (Table 2). The application of 120% chemical fertilizers produced the highest numbers of tillers and panicles, followed by 100% chemical fertilizer treatment (T_2). Compared to T_2, the integrated nutrient management treatments (T_3, T_4 and T_5) produced significantly lower numbers of tillers and panicles.

The grain and straw yield varied significantly with applying only chemical fertilizer and INM for Boro rice (Table 2). The control plot yielded only 5.14 tha^{-1} rice grain. With applying 100% chemical fertilizer, grain yield increased significantly (7.33 tha^{-1}), but by applying 120% chemical fertilizer, grain yield decreased significantly (7.05 tha^{-1}) than the recommended chemical fertilizer. The INM treatments gave statistically similar grain yield, which were statistically identical with the 120% chemical fertilizer treatment but significantly lower than the recommended chemical fertilizer treatment.

Nitrogen helped in proper filling of seeds, which resulted in higher produced plump seeds and thus the number of grains per panicle.

The straw yield followed a similar trend with INM and chemical fertilizer practices as described above for grain yield.

The percent filled grain and thousand-grain weight were influenced significantly by practicing chemical fertilizer and INM in Boro rice at the haor area (Table 2). The percent filled grain was significantly higher where no fertilizer was used and significantly lower in the 120% chemical fertilizer treatment. The other treatment gave almost a similar filled grain percentage. The thousand-grain weight for all treatments was statistically similar, but a comparatively higher thousand-grain weight was obtained with practicing recommended chemical fertilizer, followed by organic manure treatment.

Table 2. Effects of integrated nutrient management on yield parameters and grain and straw yield of BRRI dhan29, BRRI farm, Habiganj, 2016-17.

Treatments	Tiller m^{-2}	Panicle m^{-2}	GY (t ha^{-1})	SY(t ha^{-1})	Filled grain (%)	1000 grain wt. (g)
T_1	241	230	5.14	5.01	76.77	21.51
T_2	359	333	7.33	7.21	70.71	21.77
T_3	321	305	7.02	6.76	70.57	21.51
T_4	326	310	6.98	6.85	70.64	21.48
T_5	331	314	6.92	6.89	70.48	21.45
T_6	366	338	7.05	7.35	62.21	21.09
$LSD_{0.05}$	29	27	0.19	0.43	3.73	1.18
CV (%)	4.9	4.9	1.6	3.6	2.9	3.0

T_1=Fertilizer control, T_2=Recommended chemical fertilizer dose (N-P-K-S-Zn @ 130-18-60-13-4 kg ha^{-1}, respectively), T_3=Cowdung (CD) @ 2 t ha^{-1} + 50% rec. che. fert., T_4=CD @ 3 t ha^{-1}+ 50% rec. che. fert., T_5=CD @ 4 t ha^{-1}+ 50% rec. che. fert. and T_6=120% of recommended chemical fertilizer dose.

Nutrient content and nutrient uptake at the maturity stage of Boro rice

The nutrient content in grain and straw varied significantly with practicing the INM approaches (Table 3). The grain with the highest nitrogen (N) content was found in T_6 treatment, which used 120% chemical fertilizer, followed by T_2 treatment with 100% chemical fertilizer. The other INM treatments gave similar results for grain N content, and the lowest N content was observed in the fertilizer control treatment. A similar result was found for grain P and grain K content of Boro rice of BRRI dhan29 in haor soil. The straw N, P, and K content was also influenced by the application of different doses of chemical fertilizers and INM treatments. In the 120% chemical fertilizer treatment, the straw N content was higher, followed by the 100% chemical fertilizer treatment. The straw N content in organic matter treated plots was almost identical but slightly lower than chemical fertilizers treatment. A similar trend was obtained for straw P and straw K content (Table 3).

Table 3. Effects of integrated nutrient management on nutrient content in grain and straw of BRRI dhan29, BRRI farm, Habiganj, 2016-17.

Treatments	Grain N (%)	Grain P (%)	Grain K (%)	Straw N (%)	Straw P (%)	Straw K (%)
T_1	0.54	0.18	0.20	0.41	0.09	1.29
T_2	0.92	0.29	0.30	0.52	0.14	1.54
T_3	0.81	0.22	0.24	0.46	0.12	1.42
T_4	0.85	0.23	0.26	0.48	0.13	1.45
T_5	0.88	0.24	0.28	0.50	0.14	1.47
T_6	1.00	0.30	0.31	0.54	0.15	1.56
$LSD_{0.05}$	0.09	0.05	0.03	0.05	0.02	0.13
CV (%)	5.6	11.9	5.8	5.4	10.4	4.9

T_1=Fertilizer control, T_2=Recommended chemical fertilizer dose (N-P-K-S-Zn @ 130-18-60-13-4 kg ha^{-1}, respectively), T_3=Cowdung (CD) @ 2 t ha^{-1} + 50% rec. che. fert., T_4=CD @ 3 t ha^{-1}+ 50% rec. che. fert., T_5=CD @ 4 t ha^{-1}+ 50% rec. che. fert. and T_6=120% of recommended chemical fertilizer dose.

Nutrient uptake of Boro rice at the maturity stage varied significantly with chemical fertilizer and INM practices (Table 4). Higher N uptake was observed in the T_6 treatment with 120% chemical fertilizer, followed by T_2 with 100% fertilizer. Among the INM treatments, T5 (4 ton CD per ha with 50% chemical fertilizer) gave significantly higher N uptake than T_3 (2 ton CD per ha with 50% chemical fertilizer), but not in T_4 (3 ton CD per ha with 50% chemical fertilizer). The T_3 and T_4 treatments gave similar results for N uptake. Statistically similar result was obtained in the case of P and K uptake at the maturity stage of BRRI dhan29.

Table 4. Effects of integrated nutrient management on N, P and K uptake at maturity stage of BRRI dhan29, BRRI farm, Habiganj, 2016-17.

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1	48	13	75
T_2	104	31	133
T_3	88	23	113
T_4	92	25	117
T_5	95	26	120
T_6	111	32	137
$LSD_{0.05}$	5	4.9	13
CV (%)	3.2	10.7	6.3

T_1=Fertilizer control, T_2=Recommended chemical fertilizer dose (N-P-K-S-Zn @ 130-18-60-13-4 kg ha^{-1}, respectively), T_3=Cowdung (CD) @ 2 t ha^{-1} + 50% rec. che. fert., T_4=CD @ 3 t ha^{-1}+ 50% rec. che. fert., T_5=CD @ 4 t ha^{-1}+ 50% rec. che. fert. and T_6=120% of recommended chemical fertilizer dose.

Sarwar (2005) reported that yield and different yield components of rice increased significantly with the use of chemical fertilizers alone or in combination with various organic materials. Integrated use of poultry manure @ 2.5 t ha^{-1} with P, K, S, and Zn gave better grain yield than sole use of chemical fertilizer in T. Aman season (Ali *et al.*, 2018). Jisan *et al.* (2014) and Salahuddin *et al.* (2009) reported that the number of grains per panicle increased

significantly with increments in the level of nitrogen. Combined application of manures and fertilizers increased the number of grains per panicle (Malika, 2011; Rahman *et al.*, 2007 and Parvez *et al.*, 2008). (Chakraborty *et al.*, 2020) suggested for application poultry manure @ 2.5 t ha^{-1} + 50% prilled urea and full dose of other inorganic fertilizers treatment combination with BRRI dhan29 for increasing yield and improving soil health. Many reports claimed that the INM improved rice yield than the sole chemical fertilizers in Rangpur (Saha *et al.*, 2016); in Dhaka (Naher and Paul, 2017); in coastal soils (Islam *et al.*, 2024). One of the important causes of poor performance of the INM in present experiment is the relatively high organic carbon (2.27%) in the experimental field. The 2.27% organic carbon means 3.91% organic matter compared to the organic matter of 1.25% at Rangpur (Saha *et al.*, 2016), 1.19% at Dhaka (Naher and Paul, 2017), and 2.25% and 3.25% at Satkhira (Islam *et al.*, 2024). Islam *et al.* (2015) and Suresh *et al.* (2013) also reported that a combination of organic and inorganic fertilizer in soil prolongs the availability of essential nutrients, which helps to accumulate greater source and efficient translocation of photosynthates into the sink, as indicated by higher 1000-grain weight. Application of manure and fertilizers increased 1000 grain weight (Rahman *et al.*, 2007 and Parvez *et al.*, 2008). Hossain *et al.* (2010), reported that application of PM @ 2 t $ha^{-1}$with 50% soil test based (STB) chemical fertilizer gave the highest yield and nutrient (N, P, K) uptake by rice. It is well documented that the combined application of organic and inorganic fertilizers in balanced doses not only increases nutrient concentrations in plant cells but also increases crop yields (Rahman *et al.*, 2016).

Integrated nutrient management in the present experiment produced poor growth and yield compared to recommended chemical fertilizers application, which is a clear disagreement with available literature. The soil organic carbon in the present experimental field almost touched the saturation limit of the silt loam soils (Hassink, 1997). Addition of cowdung in such soils would benefit only a little because the level of organic carbon is close to the brink of the saturation point.

More than 5 t ha^{-1} yield in the control plots compared to 2.2 and 3.6 t ha^{-1} in other experimental fields (Saha *et al.*, 2016; Naher and Paul, 2017; Islam *et al.*, 2024) signifies the potentiality of the soil to supply N in the haor soil. Moreover, an increasing dose of cowdung in the present experiment decreased grain yield progressively. The application of 2 t ha^{-1} CD along with 50% of the recommended fertilizer gave 7.02 t ha^{-1}, which decreased to 6.98 t ha^{-1} with 3 t ha^{-1} CD. The grain yield further decreased to 6.92 t ha^{-1} when the CD dose was 4 t ha^{-1}. Although the yield decline with the increasing dose of CD was not significant, the declining trend is noticeable. Another important finding of the present experiment is the yield in the control plot (5.14 t ha^{-1}). Boro rice usually gives almost double the yield of the N-control plot's yield with the appropriate nutrient and other cultural management. Our results show a potentiality of the haor soil of 10 t ha^{-1} yield, but it needs a technology to achieve the target, which is a simple challenge to the BRRI scientists.

CONCLUSION

Integrated nutrient management, i.e., application of CD @ 2, 3 or 4 t ha^{-1} with 50% chemical fertilizer, did not increase the yield parameters, grain and straw yield and nutrient uptake of BRRI dhan29 in both panicle initiation and maturity stage over recommended chemical fertilizer alone in the haor areas of BRRI Habiganj farm. The 100% recommended dose of chemical fertilizer performed better than INM practices in terms of yield and nutrient uptake in the haor area. It seems the 100% recommended dose of chemical fertilizer is enough to produce maximum grain yield, and no need to apply extra chemical fertilizer, i.e., 120% of the recommended chemical fertilizer.

Furthermore, studies are recommended on the management of inorganic fertilizer to boost the yield level of 10 t ha^{-1} in the haor rice soils of single-cropped areas in the Sylhet region.

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