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Integrated Nutrient Management in Relation to Soil Fertility and Yield Sustainability under Wheat-Mung-T.aman Cropping Pattern

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Abstract: A field experiment was conducted to study the effect of continued fertilizer, organic manure and mungbean residues on soil properties and yield of crops. The grain and straw yield of wheat, mungbean and T.aman were significantly influenced by different treatment combinations of organic and inorganic fertilizations. The highest average grain yield of Wheat var. Kanchan was 4.92 t ha^{-1} in the treatment T_4 (N_{125}, P_{25}, K_{85}, S_{25}, Zn_5, Mg_{20} and B_2 kg ha^{-1}). For mungbean (var. Binamoog-2) the highest grain yield of 1.06 t ha^{-1} was obtained with inoculum + (P_{10}, K_{12} and S_4 kg ha^{-1}). The yield of T.aman (var. BRRI Dhan-32) was significantly increased when inorganic fertilizers were applied along with incorporation of mungbean stover. The highest average grain yield of rice 5.81 t ha^{-1} was recorded with N_{105}, P_{16}, K_{60} and S_8 kg ha^{-1} + mungbean stover. The residual effect of cowdung and incorporation of mungbean straw as brown manure along with inorganic fertilizer was distinct. Economics of the fertilizer uses of the total products of two cropping cycles demonstrated that the highest net benefit of US $ 1998 ha^{-1} was obtained from treatment $T_{3.3}$ (inorganic fertilizer for moderate yield + cowdung). There was no remarkable change in post harvest soil status during the period of study. However, there were considerable increase in available P but in case of K, the amount of K removed far exceeded that replenished through fertilization.

Key words : Nutrient management, yield, sustainability, cropping pattern

Introduction

Crop production system in Bangladesh is essentially rice-based. Targeting high yield with high cropping intensity is the most logical way to raise the total production from the limited land resources. With the adoption of high production technology followed by high cropping intensity, the soils of Bangladesh are depleted of many essential plant nutrients (Bhuiyan *et al.*, 1991 and Saheed, 1992). Proper soil fertility management, is therefore, of prime importance to increase crop productivity. Available data indicate that the fertility of most of our soils has deteriorated over the years (Ali *et al.*, 1997) which is mostly responsible for stagnating and in some cases, even declining crop yields (Anonymous, 1996). Moreover, indiscriminate use of inorganic fertilizers, with little or no use of organic manure and crop residue management have deteriorated the soil environment. Neither organic manure nor chemical fertilizer alone can achieve the yield sustainability separately under intensive farming where the nutrient turnover in soil plant system has been much larger. The inclusion of a legume crop in between the two cereal crops (rice and wheat) and recycling the legume crop residues to the soil as brown manuring would help to improve the soil organic matter situation. A judicious integration of macro and micro nutrients along with organic residues from a legume crop may not only help in maintaining soil fertility but may also increase crop productivity. So an effort was made to conduct a field experiment to study the effect of chemical fertilizer along with organic manures and also to evaluate the effect of mungbean residues as brown manuring on soil properties and succeeding T.aman rice.

Materials and Methods

An experiment was conducted with Wheat–Mungbean-T.aman rice cropping pattern for two cycles during 1997-98 and 1998-1999 in the Old Himalayan Piedmant Plain soil (Aquic Dystric Eutrochrept) at the Agricultural Research Station (ARS), Bangladesh Agricultural Research Institute (BARI) farm, Dinajpur. The experiment was laid out in Randomized Complete Block Design (RCBD) having unit plot size of 4 x 5m^2. The crop cycle was started by sowing wheat in Rabi (Winter) season of 1997-1998 followed by Summer mungbean in Kharif-I (Summer) and transplanted aman rice in Kharif-II (Monsoon) seasons. There were five treatments for the first crop (Wheat var. Kanchan) viz., T_1=Absolute control, T_2 =Nutrients for moderate yield based on BARC Fertilizer Recommendation Guide 1997, T_3=T_2 + cowdung 5 t ha^{-1}, T_4 = Nutrients based on soil analysis for high yield goal and T_5=T_4 + cowdung 5 t ha^{-1}. For second and third crops each treatment except T_1 was subdivided into three unit plots. The details of treatments and fertilizers management packages used for Wheat –Mungbean-T.aman rice are given in Table 1. The full dose each of cowdung, P, K, S, Zn and boron and 1/3 of N from urea were applied in wheat at the time of final land preparation. Rest of N was applied in two equal splits at CRI (Crown Root Initiation) and panicle initiation stages. For Mungbean (var. Binamoog-2) full dose of N, P, K and S were used basal during final land preparation. Biofertilizer was also used with seeds before sowing using gum acacia as the sticker as alternate of Nitrogen. For T.aman rice (var. BRRI Dhan-32) received different doses of N, P, K, S and Zn. Nitrogen was top dressed in 3 equal splits at 10, 40 and 60 days after transplanting (DAT). Weeding, thinning, mulching, spraying of fungicide and irrigation were given as and when necessary. Three composite soil samples were collected from 0-15 cm depth of the plot before fertilization and after completion of 2 complete cropping cycles. Collected soil samples have been analyzed in the laboratory for pH, organic matter, total N and available P, K and S content following the recommended methods. The plant samples (grain+straw) were collected at maturity of the each crops taking 5 plants at random from each plot and analyzed for N, P, K and S uptake by the crops folowing standard laboratory procedures.

Results and Discussion

Crop Yield

Wheat: Application of different packages of fertilization increased grain and straw yield of wheat significantly over the absolute control treatment (Table 2). The highest grain yield of 4.92 (t ha^{-1}) was obtained in treatment T_4 ($N_{125}P_{25}$ K_{85} S_{25} Mg_{20} Zn_5 B_2 kg ha^{-1}) where fertilizer was applied based

Table 1: Details of treatments used in the experiment conducted with Wheat-Mungbean-T.aman cropping pattern at ARS, BARI Farm, Rajbari, Dinajpur

Treatment	Wheat (Kanchan)							Mung (Binjamoog-2)					T.aman (BRRI Dhan-32)			
	N	P	K	S	Zn	B	Mg	N	P	K	S	B	N	P	K	S
T_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$T_{2.1}$	90	17	45	15	2			20	10	12	4		75	10	35	4
$T_{2.2}$	90	17	45	15	2			I*	10	12	4		45	5	17.5	0
$T_{2.3}$	90	17	45	15	2			I*	0	0	0		45	0	0	0
$T_{3.1}$	$T_{2.1}$	+	CD					20	10	12	4		75	10	35	4
$T_{3.2}$	$T_{2.2}$	+	CD					I*	10	12	4		45	5	17.5	0
$T_{3.3}$	$T_{2.3}$	+	CD					I*	0	0	0		45	0	0	0
$T_{4.1}$	125	25	85	25	5	2	20	20	12	18	8		105	16	60	8
$T_{4.2}$	125	25	85	25	5	2	20	I*	12	18	8		60	8	30	0
$T_{4.3}$	125	25	85	25	5	2	20	I*	0	0	0		60	0	0	0
$T_{5.1}$	$T_{4.1}$	+	CD					20	15	18	8		105	16	60	8
$T_{5.2}$	$T_{4.2}$	+	CD					I*	15	18	8		60	8	30	0
$T_{5.3}$	$T_{4.3}$	+	CD					I*	0	0	0		60	0	0	0

Note, I* = Rhizobium Inoculum (2 kg ha^{-1}), CD = Cow dung (5 t ha^{-1}) and Fertilizers are in kg ha^{-1}

Table 2: Average grain and straw yield of cropping pattern Wheat-Mungbean-T.aman rice as affected by different fertilizer management packages during 1997-98 and 1998-99.

Treatment	Grain yield (t ha^{-1})						
	Wheat			Mung*	T.aman		
	1997	1998	Mean	1998	1998	1999	Mean
T_1	2.40c	2.33c	2.37	0.59l	3.03g	2.77e	2.90
$T_{2.1}$	4.88ab	4.12b	4.50	0.71fg	5.28de	4.78abc	5.03
$T_{2.2}$	-	-	-	1.06a	4.97ef	4.43cd	4.70
$T_{2.3}$	-	-	-	0.93c	4.79f	4.05d	4.42
$T_{3.1}$	4.99ab	4.27b	4.63	0.79de	5.72bc	5.13ab	5.43
$T_{3.2}$	-	-	-	0.99b	5.00cd	4.83abc	4.92
$T_{3.3}$	-	-	-	0.93bc	5.35d	4.53bcd	4.94
$T_{4.1}$	5.10a	4.73a	4.92	0.78de	6.18a	5.43a	5.81
$T_{4.2}$	-	-	-	0.67gh	5.92ab	4.66bcd	5.29
$T_{4.3}$	-	-	-	0.82d	5.57cd	4.39cd	4.98
$T_{5.1}$	4.32b	4.37b	4.75	0.64hi	5.64bcd	4.89abc	5.27
$T_{5.2}$	-	-	-	0.63hi	5.31de	4.43cd	4.87
$T_{5.3}$	-	-	-	0.77ef	5.29de	4.25cd	4.47
Straw Yield (t ha^{-1})							
T_1	5.63b	4.83b	5.23	1.10	3.67d	3.53g	3.60
$T_{2.1}$	8.30a	8.49a	8.40	1.18	6.14bc	6.00bc	6.07
$T_{2.2}$	-	-	-	1.66	6.01bc	5.72cd	5.87
$T_{2.3}$	-	-	-	1.80	6.38b	5.02ef	5.70
$T_{3.1}$	8.74a	9.04a	8.89	1.58	7.45a	6.56a	7.01
$T_{3.2}$	-	-	-	1.78	6.52b	6.10bc	6.31
$T_{3.3}$	-	-	-	1.96	6.05bc	5.60cd	5.83
$T_{4.1}$	8.31a	9.34a	8.83	1.49	7.67a	6.50ab	7.09
$T_{4.2}$	-	-	-	1.39	6.55b	5.43de	5.99
$T_{4.3}$	-	-	-	1.52	6.18bc	5.27de	5.73
$T_{5.1}$	8.91a	9.17a	9.04	1.09	6.56b	5.67cd	6.12
$T_{5.2}$	-	-	-	1.36	5.78bc	5.27de	5.33
$T_{5.3}$	-	-	-	1.41	5.52c	4.13f	4.98

*In 1999 the crop damaged due to heavy rain during pod filling stages.

Table 3: Nutrient uptake by crops grown in Wheat-Mungbean-T.aman rice as affected by different treatment combinations of organic and inorganic fertilization.

Treatments	Total nutrient uptake (kg ha^{-1}) by the crops of the tested pattern			
	N	P	K	S
T_1	125	34	108	22
$T_{2.1}$	241	102	228	44
$T_{2.2}$	251	99	232	41
$T_{2.3}$	249	107	240	42
$T_{3.1}$	275	74	268	47
$T_{3.2}$	268	70	254	44
$T_{3.3}$	269	69	209	43
$T_{4.1}$	295	81	271	55
$T_{4.2}$	278	83	249	52
$T_{4.3}$	274	70	244	47
$T_{5.1}$	222	72	257	47
$T_{5.2}$	224	69	246	45
$T_{5.3}$	224	68	241	45
Range	125-295	34-107	138-271	22-55

Table 4: Status of available nutrients as affected by Wheat-Mung-T.Aman cropping pattern and different inorganic and organic fertilizer combination after two year of cropping at ARS, BARI, Rajbari, Dinajpur.

Treatment	pH	OM (%)	Total N (%)	Available nutrients (ppm)				Exchangeable actions (meq%)		
				P	S	Zn	B	K	Ca*	Mg*
Initial soil (1997)										
	5.4	1.1	0.11	15.0	15.0	1.4	0.65	0.11	1.8	0.80
Post harvest soil after two years of cropping										
T_1	5.3	0.90	0.07	13	11	1.20	0.71	0.07	-	-
$T_{2.1}$	5.2	0.96	0.08	15	13	1.30	0.85	0.08	-	-
$T_{2.2}$	5.1	0.94	0.08	13	12	1.25	0.75	0.08	-	-
$T_{2.3}$	5.2	0.95	0.07	13	11	1.20	0.74	0.07	-	-
$T_{3.1}$	5.2	1.03	0.09	15	15	1.35	0.80	0.09	-	-
$T_{3.2}$	5.0	0.99	0.08	14	14	1.25	0.72	0.08	-	-
$T_{3.3}$	5.2	0.98	0.08	13	14	1.35	0.75	0.07	-	-
$T_{4.1}$	5.1	1.00	0.08	15	17	1.30	0.72	0.10	-	-
$T_{4.2}$	5.3	0.99	0.07	14	16	1.20	0.72	0.09	-	-
$T_{4.3}$	5.1	0.97	0.08	14	15	1.35	0.76	0.09	-	-
$T_{5.1}$	5.0	1.08	0.09	17	17	1.30	0.73	0.10	-	-
$T_{5.2}$	5.1	1.04	0.08	15	15	1.20	0.85	0.08	-	-
$T_{5.3}$	5.2	1.06	0.08	15	16	1.10	0.70	0.09	-	-

* Post harvest soil analysis for Ca and Mg has not been done.

Table 5: Partial budget analysis for fertilizer use in crop production under Wheat-Mung-T.aman pattern at ARS, BARI, Dinajpur.

Treatments	Net yield (kg ha^{-1})		Gross field profit (Tk ha^{-1})			Variable money cost (Fertilizer) Tk ha^{-1}	Variable opportu-nity cost Tk ha^{-1}	Total variable cost Tk ha^{-1}	Net benefit Tk ha^{-1}	Net benefit $ha^{-1}
	Grain	Straw	Grain	Straw	Total					
T_1	5863	9927	55600	9927	65527	-	-	-	65527	1191
$T_{2.1}$	10235	15654	89845	15654	105499	8247	715	8962	96537	1755
$T_{2.2}$	10263	15928	98440	15928	114368	6784	715	7499	106869	1943
$T_{2.3}$	9845	15904	92480	15904	108384	4981	660	5641	102743	1863
$T_{3.1}$	10848	17376	95975	17376	113351	9247	715	9962	103389	1880
$T_{3.2}$	10539	16980	98690	16980	115670	7784	715	8499	107717	1959
$T_{3.3}$	10503	16679	97140	19379	116519	5981	660	6641	109878	1998
$T_{4.1}$	11504	17406	100345	17406	117751	16764	715	17479	100272	1823
$T_{4.2}$	11029	16207	93755	16207	109962	14770	715	15485	94477	1718
$T_{4.3}$	10719	16083	96300	16083	112383	11395	660	12055	100328	1824
$T_{5.1}$	10264	16248	88375	16248	104623	17764	715	18479	86144	1566
$T_{5.2}$	9853	15931	85445	15931	101376	15770	715	16485	84891	1543
$T_{5.3}$	9883	15477	88930	15477	104407	12395	660	13055	91352	1661

Table 6 : Marginal analysis of the undominated fertilizer response data.

Net benefit (Tk ha^{-1})	Treatment	Variable	Change from next highest benefit		
			Marginal increase in	Marginal increase in	Marginal rate of return
109878	$T_{3.3}$	6641	7135	1000	7.14
102743	$T_{2.3}$	5641	37216	5641	6.06
65527	T_1	000	-	-	-

on soil test. It was also observed that treatment T_2 (N_{90} P_{17} K_{45} S_{15} Zn_2 kg ha^{-1}) which received only inorganic fertilizer based on BARC Fertilizer Recommendation Guide 1997 and T_3 (which received nutrients based on fertilizer recommendation guide + cowdung 5 t ha^{-1}) and treatment T_5 (nutrient received based on soil test cowdung + 5 t ha^{-1}) produced statistically identical yield with T_4 (nutrient received based on soil analysis). This is in agreement with the findings of Panaullah *et al.* (1998) and Rokeya (1999).

Mungbean: Grain and stover yield of mungbean increased significantly due to treatments over control (Table 2). The highest grain yield of 1.06 t ha^{-1} was recorded in treatment $T_{2.2}$ (Inoculum + P_{10} K_{12} and S_4 kg ha^{-1}) along with residual effect of fertilizer applied during wheat season. The lowest of yield of 0.59 t ha^{-1} was obtained in control treatment where no fertilizer was applied. Although mungbean was not attractive for pod yield, yet growing this crop before T.aman may provide substantial amount of biomass to soil. It is interesting to note that there is a good scope of reduction of N 1/3 in T.aman rice if the mungbean stover is mixed with the soil.

T.aman: Grain and straw yield of T.aman rice (var. BARRI Dhan-32) under Wheat-Mungbean-T.aman cropping pattern are presented in Table 2. The results indicated that grain and straw yields were significantly increased when inorganic fertilizers were applied along with incorporation of mungbean

stover. The highest average grain yield of rice (5.81 t ha^{-1}) was recorded in $T_{4.1}$ (N_{105} P_{16}, K_{60} and S_8 kg ha^{-1}) where fertilizers were applied based on soil analysis. As expected the lowest grain yield of 2.90 t ha^{-1} was obtained in the control plots. However, grain yield obtained from moderate level application of chemical fertilizers along with residual organic manure was statistically identical with that produced by the higher doses of chemical fertilizer along with residual organic manure ($T_{5.1}$). Like grain yield, the straw yield followed the same trend. The residual effect of cowdung and mungbean stover as brown manure along with inorganic fertilizer was distinct. Spectacular response of residual effect of cowdung and mungbean stores as brown manure along with inorganic fertilizer to the following rice have been reported by Panaullah *et al.* (1998).

Nutrient uptake: The amounts of N, P, K and S adsorbed by Wheat-Mungbean-T.aman rice as affected by different organic and inorganic fertilization are presented in Table 3. Nutrient uptake increased with increase of yield. The highest uptake was found in $T_{4.1}$ treatment (except P) where fertilizer was added on the basis of soil analysis. The nutrient uptake ranged among the treatments N (125-295), P (34-107), K (138-271) and S (22-55) kg ha^{-1}. In all cases, the lowest uptake was recorded in the control treatment. The nutrient uptake of the cropping pattern found to follow the order : K > N > P > S.

Soil fertility status: The status of soil pH, organic matter, total N, and available P, K and S in initial soil as well as in soil after completion of 2 cycles of Wheat-Mungbean-T.aman rice cropping pattern are reported in Table 4. The inclusion of mungbean in between two cereal crops has brought no appreciable changes in the post harvest soil status during the period of the study. Yadav *et al.* (1999) corroborate the results of the present findings. There were considerable decreases in pH and organic matter content appeared in most cases. However, available P was slightly increased but the amount of K removed for exceeded that replenished through fertilization.

Economics of fertilizer uses: Economics of fertilizer uses have been calculated on the total products of two cropping cycles following partial budget analysis and marginal analysis as described by Perrin *et al.* (1979) and are presented in Table 5 and 6. The highest net benefit of US$ 1998 ha^{-1} was obtained from the $T_{3.3}$ followed by US$ 1959 and US$ 1943 ha^{-1} in $T_{3.2}$ and $T_{2.2}$ treatments. Marginal analysis of undominated fertilizer response data (Table 6) recorded the highest marginal rate of return (714/%) in $T_{3.3}$ followed by 660% in $T_{2.3}$ treatment. It may be concluded that for wheat cultivation that the marginal farmer's of the locality may advised to go for treatment $T_{3.3}$ (N_{90} P_{17} K_{45} Zn_2 kg ha^{-1} + cowdung 5 t ha^{-1} and for T.aman rice only N_{45} kg ha^{-1} is sufficient along with mungbean residues as brown manuring is economically more beneficial than the other treatments. But the farmer's who are able to invest more, may go for treatment $T_{4.1}$ (nutrient based on soil analysis) for maximum economic benefit which will supply balanced nutrient that may also help to maintain soil fertility against soil degradation.

It is clearly concluded that there is a good scope of increasing crop yields through the use of balanced fertilization based on soil analysis. Inclusion of legume in between two cereals would help to reduce the application of 1/3 N of the recommended dose in the following T.aman rice. It could give comparable yield of T.aman rice as obtained with full dose of N fertilizer. Thus integrated nutrient management involving inorganic fertilizers with organic manures have greater potential in stabilizing the yields over a period of time to provide total nutrition for rice-wheat system.

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References

Ali, M.M., S.M. Shaheed and D. Kubota, 1997. Soil degradation during the period 1967-1995 in Bangladesh. II. Selected chemical characters. Soil Sci. Plant Nutr., 43: 870-890.

Anonymous, 1996. The Bangladesh Rice Res. Insti. Gazipur, Bangladesh.

Bhuiyan, N.I., A.L. Shah and G.M. Panullah, 1991. Effect of N, P and K fertilization on the grain yield of transplanted rice and soil fertility. A long-term study. Bangladesh J. Soil Sci., 21: 41-50.

Panaullah, G.M., M.A. Saleque, M.J. Abedin and M. Ishaque, 1998. Integrated nutrient management with inorganic fertilizers, crop residues and organic manures for Wheat-Mungbean-T.aman rice cropping pattern. Proc. of the national workshop on integrated nutrient management for crop production and soil fertility, 24-25.

Perrin, R.K., D.L. Winkclman, E.R. Moscardi and J.R. Anderson, 1979. Economics Training Manual. Information Bull. No. 27, Cimmyt, Maxico.

Rokeya, M.K., 1999. Integrated nutrient management for Wheat-T.aus-T.aman rice cropping pattern under the Old Brahmaputra Flood Plain of Bangladesh. M.S. Thesis. Department of Soil Science, Bangladesh Agric. Univ., Mymensingh.

Saheed, S. M., 1992. Land and Soil Resources Utilization Guide. In proceeding "Inter congress conference of commission IV on Improving Soil Management for Intensive Cropping in Tropics and Sub-Tropics" Dhaka, Bangladesh, 175-183.

Yadav, D.S., A.K. Kumar and R.K. Singh, 1999. Long-term nutrient management for sustainable production in Rice-Wheat cropping system. Proc. of BRRI-IRRI joint workshop on long-term experiments on soil fertility in Rice-based cropping systems. Bangladesh Rice Res. Inst., 8-11.