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EFFECT OF INTEGRATED USE OF ORGANIC MANURES AND CHEMICAL FERTILIZERS ON YIELD, NUTRIENT UPTAKE AND NUTRIENT BALANCE IN THE BUSH BEAN - T.AUS - T. AMAN CROPPING PATTERN

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Abstract

A study was made on integrated nutrient management in the Bush bean –T. Aus –T. Arnan cropping pattern over three years at BRRI Farm, Gazipur (AEZ-28) during 2000-02. Different packages of chemical fertilizers in combination with organic materials (cowdung and rice straw/bush bean stover) were evaluated to find out a suitable combination for obtaining higher yield of crops. There was a positive effect of crop residue recycling and residual effect of cowdung on the yield of the next crops. Both the soil test based fertilizer and the cowdung with IPNS basis fertilizer treatments gave higher pod yield of bush bean. For T. Aus rice, the highest yield was obtained with the treatment where bush bean stover was used along with IPNS based chemical fertilizer. Again the highest yield of T. Aman rice was observed in the residual effect of cowdung with reduced amount of fertilizer. An excess N uptake was recorded where N was added as fertilizer only. The apparent balance (nutrient added through manures and fertilizers minus nutrient removed by crops) for both N and K was negative while that for P & K was mostly positive.

Key Words: IPNS, cowdung, rice straw, bush bean, rice, nutrient balance.

Introduction

Cropping patterns in Bangladesh are mainly rice-based. Plant nutrients in soil, whether naturally endowed or artificially maintained, is a major factor of the success or failure of a crop production system. Intensive rice cropping with constant and high fertilizer inputs indicated a declining trend in rice yield (Cassman and Pinagli, 1995), and this decline of grain yield can be attributed to soil nutrient depletion, as evidenced from long term experiments in Asia (Dobermann and Fairhurst, 2000). Available data indicate that the fertility of Bangladesh soils has deteriorated over the years (Ali *et al.*, 1997 a, b). It is apparent that sustainability of crop production system in future will mainly depend on integrated nutrient management and balanced supply of nutrients. Crop residue management practice influences agricultural sustainability by altering the organic matter status, physical and chemical properties of soil with all interest for better microbial activity and diversity (Doran and Smith, 1987).

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Incorporation of crop residue, cowdung increases the organic carbon and nutrient content of soils (Saha *et al.,* 2007) and increases crop yields (Bhatnagar *et al.,* 1983). Brown manure (mungbean, bushbean stover) can be a good source of additional N for rice. Incorporation of mungbean stover is agronomically viable and economically profitable management for rice (Saha *et al.,* 2000). Rice straw incorporation increased soil organic matter content and increased crop yield in the both rice -rice (Saha *et al*., 2007) and rice-wheat (Kavimandan *et al.,* I 987) systems. Unless the organic matter factor is seriously considered in the cropping systems, it would be difficult to achieve the goal of increased and sustained crop productivity. Now it is important to develop an integrated organic-inorganic fertilization programme for achieving higher crop yield without affecting soil health. In this respect, inclusion of a brown manure crop within the cropping system deserves special attention. Considering these points, a field study was conducted with an integrated nutrient management approach in the Bush bean –T. Aus –T. Aman cropping sysem.

Materials and Method

A field trial with Bush bean (BARI Jharshim-1) -T. Aus (BR26) -T. Aman (BRRI dhan-39) cropping system was conducted at BRRI Farm, Gazipur (AEZ-28 and land type-HL) during 2000-02. The soil of the experimental field was silt loam in texture with pH 6.30, organic carbon (OC) 1.01%, total N 0.1%, available P 4 ppm, exchangeable K 0.18 Cmol kg^{-1} available S 11.6 ppm and available Zn 1.4 ppm. The experiment was laid out in a randomized complete block design with six treatment combinations and three replications. Detailed treatments descriptions for all three crops are given in Table 1.

Bush bean was the first crop in the pattern. In the two rice seasons (Kharif-I & II) each original plot under treatments T_3 and T_5 was divided into four and two sub-plots, respectively.

The sources of N, P, K, S, and Zn were urea, triple superphosphate, muriate of potash, gypsum, and zinc sulfate, respectively. Fertilizers were applied to each crop according to the treatments (Table 2). In treatment T_5, cowdung @ 5 t/ha on oven dry (OD) basis was applied once a year before sowing bush bean and the chemical fertilizers were applied to this plot as integrated plant nutrition system (IPNS) basis.

Bush bean

Full doses of P, K, S, Zn, and organic materials were applied during final land preparation as basal dose. Nitrogen as per treatment was applied in two equal

splits at 15 and 35 days after sowing. Bush bean was grown maintaining line-to-line 30 cm spacing. The seed rate of Bush bean was 100 kg/ha. T. Aman rice straw 5t/ha (OD basis) was incorporated 7 days prior to Bush bean sowing (T_4). Bush bean was sown in line in December.

T. Aus and T. Aman rice

All P, K, S, and Zn as per treatments were applied as basal and thoroughly incorporated with soil before transplanting. Nitrogen as per treatment was applied in three equal splits (basal 25-30 DAT + 55-60 DAT). Bush bean stover was incorporated at *5* t/ha as oven dry basis at 7 days prior to T. Aus planting (T_4). After T. Aus harvest, the rice straw was incorporated 7 days prior to T. Aman rice planting (T_4). Rice crops were grown maintaining 20 cm x 20 cm spacing in each season. T. Aus was transplanted in March and T. Aman in August.

Table 1. Treatment descriptions of the experiment.

Rabi (Bush bean) (BARI Jahrshim 1)	Kharif I (T. Aus, BR26)	Kharif II (T. Aman, BRRIdhan-39)
T_1 = Absolute control (no fertilizers)	T_1 = Absolute control (no fertilizers)	T_1 = Absolute control (no fertilizers)
T_2 = BARC fertilizer recommendations (AEZ basis, MYG)	T_2 = BARC fertilizer recommendations (AEZ basis, MYG)	T_2 = BARC fertilizer recommendations (AEZ basis, MYG)
T_3 = STB (Soil test basis); (only inorganic fertilizer doses, HYG)	T_{3a} = Rec. dose for HYG	T_{3a} = Rec. dose for HYG
	T_{3a} = Rec. dose for HYG	T_{3a} = Rec. dose for HYG
	T_{3a} = Rec. dose for HYG	T_{3a} = Rec. dose for HYG
T_4= Recycled crop residues + IPNS[2] basis Chemical fertilizers doses for HYG	T_4= Recycled crop residues + IPNS[2] basis Chemical fertilizers doses for HYG	T_4= Recycled crop residues + IPNS[2] basis Chemical fertilizers doses for HYG
T_5 = Recycled crop t/ha on oven dry basis + IPNS basis inorganic fertilizers for HYG	T_{5a} = Rec. dose for HYG	T_{5a} = Rec. dose for HYG
	T_{5b}= 100% N + 50% PKST	T_{5b}= 100% N + 50% PKST
T_6 = Local farmer's practices	T_6 = Local farmer's practices	T_6 = Local farmer's practices

Note: CR = Replenishment of quantities of nutrients removed by the preceding crop. In calculating nutrient doses, contributions from the organic residue considered along with chemical fertilizers

Table 2. Details of nutrients used in the Bush bean in a Bush bean- T. Aus- T. Aman cropping pattern.

Treatment	Nutrient applied (kg/ha)														
	Bushben					T. Aus rice					T. Aman rice				
	N	P	K	S	Zn	N	P	K	S	Zn	N	P	K	S	Zn
T_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2	40	20	25	10	0	55	12	30	7	2	55	12	30	7	2
T_{3a}	60	40	25	12	0	87	20	29	10	0	87	20	29	10	0
T_{3b}	60	40	25	12	0	87	10	14.5	5	0	87	10	14.5	5	0
T_{3c}	60	40	25	12	0	87	10	29	5	0	87	10	29	5	0
T_{3d}	60	40	25	12	0	87	608	34	8.8	0.1	87	19	219	11	0.35
T_4	35	39	10	11	0	77	18.1	19.1	2.2	0	52	11	0	4	0
T_{5a}	10	30	0	4.5	0	87	20	29	10	0	87	20	29	10	0
T_{5b}	10	30	0	4.5	0	87	10	14.5	5	0	87	10	14.5	5	0
T_6	16	16	12	8	0	70	10	15	0	0	70	10	15	0	0

Note: For Bush bean, nutrient doses were estimated on assumption. Farmer's practice for T. Aus and T. Aman were determined through questionnaire survey of 25 local farmers.

5 t CD = 50-10-100-8-0 kg N-P-K-S-Zn, respectively.
0.5t Bush bean stover = 10-2-10-8-0 kg N-P-K-S-Zn, respectively.
5t T.Aus rice straw = 35-9-100-6-0.2 kg N-P-K-S-Zn, respectively.
5t T.Aman rice straw =35-7-100-7-0 kg N-P-K-S-Zn, respectively.

Appropriate cultural and management practices were followed during each crop season. Edible green pods of Bush bean were harvested from the whole plot and the yield was adjusted at oven dry basis. The rice crops were harvested at maturity from 2.5m x 2 m area. The grain yields were recorded at 14% moisture and straw yields at oven dry basis.

Results and discussion

Bush bean

Application of different fertilizer packages increased pod yield significantly over control plot and the highest pod yield was obtained with T_3 treatment where soil test based fertilizer was applied (Table 3). The three years' average pod yield of Bush bean was generally higher with application of different fertilizer doses (T_2-T_6), varying from 0.74 to 1.07 t/ha, compared to that obtained with no fertilization (0.56 t/ha). The pod production in farmers' doses (T_6) vas relatively low (0.74 t/ha), which was 31% lower than that obtained with T_3 treatment. The yield recorded from BARC recommended fertilizer dose (T_2) also gave better

yield (0.86 t/ha) than that with farmers' doses in T_6 treatment. Pod yield due to T_3 treatment increased by 24% as compared to T_2. Application of cowdung (T_5) and recycled crop residues (T_4) increased yield over other treatments except T_3.

T.Aus and T.Aman rice

In T. Aus (2000-2002), the average highest rice yield was obtained from T_4 treatment where Bush bean stover was recycled and chemical fertilizers were applied as IPNS basis. The grain yields of T_4 T_{5a} and T_{5b} were comparable. Practicing the T_{5b} treatment, 50% of PKS fertilizer can be saved in T. Aus season indicating a residual effect of cowdung applied in Bush bean crop. Aus rice yield was relatively low in BARC recommended and farmer's practice fertilizer doses (Table 3).

In T. Aman rice 2000-02, the average grain yield ranged from 2.57 t/ha (T_1) to 3.75 t/ha (T_{5b}). Higher grain yield was obtained from treatment (T_{5b}), where 100%N + 50% PKS (STB doses) were applied in T. Aman season and CD was applied in the previous Bush bean crop. The grain yields in 'b', c' and 'd' sub-plots were comparable to the yield of 'a' sub-plots ol 13 treatments. The yields in these subplots were identical (Table 3).

Table 3. Effect of different fertilizer packages on the pods/grain yield of crops in the Bushbean-T. Aus- T. Aman cropping pattern.

Treatment	Bush bean (BARI jhar shim-1)				Treat.	T. Aus rice (BR-26)				Treat.	T. Aman rice (BRRI dhan-39)			
	Pod yield (t/ha)					Grain yield (t/ha)					Grain yield (t/ha)			
	2000	2001	2002	Mean		2000	2001	2002	Mean		2000	2001	2002	Mean
T_1	0.42	0.32	0.94	0.56	T_1	2.01	2.20	1.33	1.85	T_1	3.06	2.14	2.51	2.57
T_2	0.67	0.56	1.36	0.86	T_2	2.04	2.74	1.67	2.15	T_2	3.84	2.98	3.04	3.29
					T_{3a}	2.45	2.84	2.14	2.48	T_{3a}	4.473	3.08	3.18	3.56
T_3	0.85	0.77	1.59	1.07	T_{3b}	2.41	2.92	2.35	2.56	T_{3b}	4.43	3.08	3.18	3.56
					T_{3c}	2.27	2.89	2.00	2.39	T_{3c}	4.30	3.347	3.27	3.64
					T_{3d}	2.39	2.78	2.59	2.59	T_{3d}	4.37	2.55	3.05	3.32
T_4	1.00	0.34	1.42	0.92	T_4	2.21	3.90	2.76	2.96	T_4	4.41	2.91	3.39	3.57
T_5	0.94	0.50	1.53	0.99	T_{5a}	2.414	3.29	2.81	2.84	T_{5a}	4.41	3.31	3.46	3.75
					T_{5b}	2.45	3.48	2.89	2.94	T_{5b}	4.53	3.21	3.51	3.75
T_6	0.53	0.45	1.25	0.74	T_6	2.52	21.74	1.69	2.32	T_6	4.14	2.94	3.15	3.41
LSD	0.25	0.14	0.34			NS	0.42	0.39			0.50	0.19	0.64	
CV (%)	18.8	14.3	13.5			16.3	8.2	10.3			7.0	3.9	11.7	

The result indicates a beneficial residual effect of PKS fertilizers applied to the previous Bush bean and T. Aus crops of the cropping pattern. In this season, reduced dose of PKS (50%) can be applied instead of full STB dose. The residual effect of cowdung was also observed in T. Aman season. The highest grain yield (3.75t/ha) was obtained from T_{5b} treatment where l00% N and 50 % PKS fertilizers (STB basis) were applied.

Table 4. Effect of different fertilizer packages on the stover/straw yield of crops in the Bushbean-T. Aus- T. Aman cropping pattern.

Treatment	Bush bean (BARI jhar shim-1)				Treat.	T. Aus rice (BR-26)				Treat.	T. Aman rice (BRRI dhan39)			
	Stover (t/ha)					Straw yield (t/ha)					Straw yield (t/ha)			
	2000	2001	2002	Mean		2000	2001	2002	Mean		2000	2001	2002	Mean
T_1	0.24	0.37	0.77	0.46	T_1	3.14	3.86	2.36	3.12	T_1	2.78	2.39	2.97	2.71
T_2	0.24	0.69	0.89	0.61	T_2	4.95	5.16	3.93	4.69	T_2	4.14	4.23	5.48	4.62
					T_{3a}	4.35	5.18	3.71	4.41	T_{3a}	5.15	4.66	5.42	5.08
T_3	0.36	0.95	1.11	0.81	T_{3b}	4.75	4.71	5.23	4.90	T_{3b}	4.55	4.16	6.00	4.90
					T_{3c}	5.23	4.41	4.98	4.87	T_{3c}	4.74	4.39	5.58	4.90
					T_{3d}	5.82	5.05	4.88	5.25	T_{3d}	4.58	3.97	4.97	4.51
T_4	0.40	0.48	1.14	0.67	T_4	5.70	4.97	5.69	5.45	T_4	4.69	3.82	5.91	4.81
T_5	0.40	0.88	1.20	0.83	T_{5a}	4.90	4.97	4.52	4.80	T_{5a}	4.57	4.51	6.49	5.19
					T_{5b}	4.90	4.78	4.57	4.75	T_{5b}	4.98	3.91	5.99	4.96
T_6	0.25	0.67	0.93	0.62	T_6	4.13	4.51	3.70	4.11	T_6	3.95	4.55	4.56	4.35
LSD	0.09	0.25	0.29			1.03	0.88	0.95			0.58	0.84	0.87	
CV (%)	14.8	19.0	16.3			12.6	10.8	12.7			7.60	12.00	9.60	

The stover and straw yields from 2000 to 2002 are presented in Table 4. The average stover yield of Bush bean was found higher with different fertilizers application (T_2 - T_6), showing from 0.61 to 0.83 t/ha, in comparison with that obtained from control treatment (0.46 t/ha). The trend of the effect of different fertilizer doses on the stover yield of Bush bean was similar to that of the grain yield. In T. Aus season (2000-2002), the average straw yield ranged from 3.12 t/ha (in control plot) to 5.45 t/ha (in T_4). A higher straw yield was obtained from treatment (T_4), in which Bush bean stover was incorporated and chemical fertilizer were applied as IPNS basis. The straw yields in sub-plots T_{3b}, T_3, and T_{5b} were comparable. Similar trend in straw yields of T. Aman crops were observed.

Nutrient uptake

The amount of N, P, K, S, and Zn uptake by Bush bean, T. Aus, and T. Aman crops are presented in Table *5*. The amounts varied widely with the treatments

and yield levels. As biomass production (Pod + stover + rice grain + rice straw) was higher in STB recycled crop residues + IPNS chemical fertilizer and cowdung + IPNS chemical fertilizer treated plots, the nutrients uptake was also higher in those plots. Recycled crop residues and addition of cowdung with IPNS basis chemical fertilizer slightly improved nutrient uptake compared to STB treatment where only inorganic fertilizers were used.

Apparent nutrient balance

Nitrogen replenishment through chemical fertilizer, crop residue recycling, and cowdung addition was not enough to balance N removal by crops since much of the applied N was lost from the soil. Thus, 242 to 306 kg N/ha appeared to have been removed in excess of the amounts added (Table *5).* The P balance was favourable as expected. An appreciable amount of P was accumulated in fertilized plots, especially in the plots where cowdung, crop residue, STB fertilizer and crop removal basis PKS were applied. Sulphur was accumulated in the plots where STB fertilizers and crop residues were added. However, the lowest amount of S removed from the soils of cowdung treated plot. The positive effect of these elements was reflected in the subsequent crops. But in case of K, it was evident that this element was removed in large excess of the amount added as fertilizer in most of the treatments. The negative balance of K ranged from -120 to -807 kg/ha in three years (Table *5).* However, treatments T_{3d} and T_4, where crop removal basis K and crop residues were applied, respectively, showed a less negative balance of K where K deficiency may arise after a long time. The K fertilizer dose, therefore, needs to be carefully fixed. Where the rice straw (rich in K content) was incorporated to the soil, the negative balance was narrower.

Table 5. Effect of different fertilizer packages on the nutrient uptake and balance in the Bush bean -T. Aus - T. Aman cropping pattern.

Treatment	Nutrient added (kg/ha)					Nutrient uptake (kg/ha)					Nutrient balance (kg/ha)				
	N	P	K	S	Zn	N	P	K	S	Zn	N	P	K	S	Zn
T_1	60	2	42	0	0	339	87	571	56	1.3	-279	-85	-529	-56	-1.3
T_2	242	134	297	72	12	534	129	907	88	2.0	-292	+5	-610	-16	+10
T_{3a}	341	242	291	96	0	615	136	970	89	2.8	-274	+1406	-679	+7	-2.8
T_{3b}	341	182	205	66	0	621	145	1012	86	2.0	-290	+37	-807	-20	-2.0
T_{3c}	341	182	291	66	0	615	136	1033	86	2.1	-274	+46	-742	-20	2.1
T_{3d}	341	199	876	95	1.4	585	142	1030	103	2.1	-242	+57	-133	+7	-1.1
T_4	385	266	910	113	1.5	627	146	1030	103	2.1	-242	+120	-120	+10	-0.6
T_{5a}	341	331	417	94	1.8	647	148	1012	98	2.2	-306	+183	-595	-4	-0.4
T_{5b}	341	271	331	64	1.8	625	142	1051	102	2.3	-284	+129	-720	-38	-0.5
T_6	248	110	168	247	0	534	114	836	76	1.7	-286	-4	-668	-52	-1.7

The added N was estimated based on irrigation water and BNF. The P and K was estimated fiom irrigation water only

Conclusion

Soil test based chemical fertilizer application and 1PNS based chemical fertilizer adjusted with the nutrient supplied by recycled crop residues and cowdung @ *5* t/ha (oven dry basis) showed similar yield performance on Bush bean. Recycled Bush bean stover along with IPNS based chemical fertilizer application or residual effect of cowdung + 100% N and 50% PKS of STB gave the highest yield in T. Aus rice. In T. Aman rice, residual effect of cowdung along with reduced doses of chemical fertilizer (100% N, 50% of P, K, and S) in the field trial substantially increased the grain yield.

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